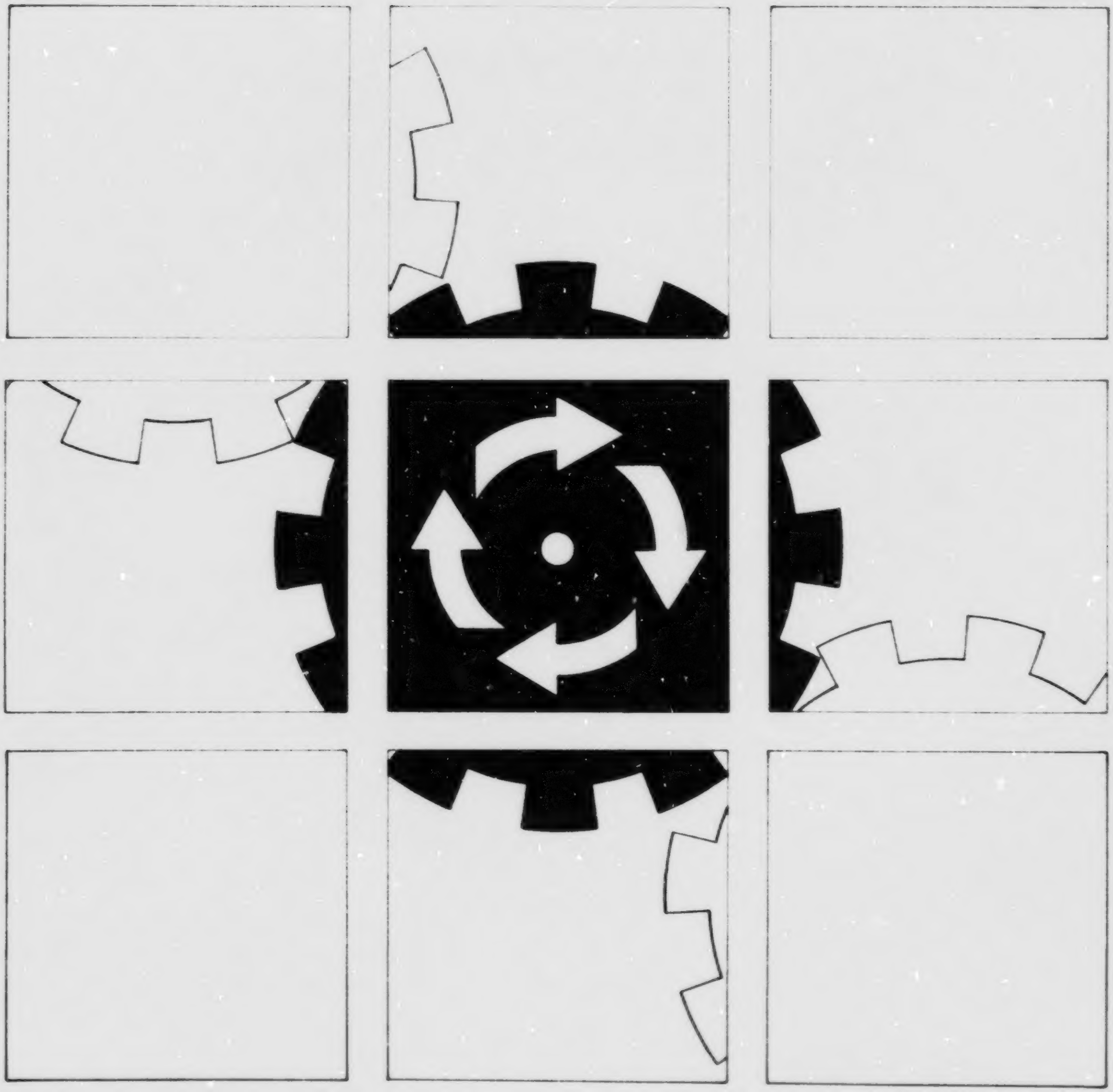
OWMC

Ontario
Waste Management
Corporation
System
Development
Project

The Proctor & Redfern Group

ONTARIO RESEARCH FOUNDATION
PROCTOR & REDFERN LIMITED
WESTON DESIGNERS-CONSULTANTS

Waste Reduction Opportunities Study



NOTE

This report was completed in draft form prior to OWMC's decision to terminate its relationship with Proctor & Redfern Limited. Aware of public interest in the study and impressed by its quality, but also aware of the need for corrections and minor changes in the draft, OWMC arranged for the completion of this final report.

We wish to acknowledge the contributions of the Ontario Research Foundation, Proctor & Redfern Limited and Weston Designers-Consultants.

May, 1983

WASTE REDUCTION
OPPORTUNITIES STUDY

January, 1983

Ontario Research Foundation
Proctor & Redfern Limited
Weston Designers - Consultants

ONTARIO WASTE MANAGEMENT CORPORATION

BACKGROUND INFORMATION

The Ontario Waste Management Corporation (OWMC) is a provincial crown agency created in 1981 by the Ontario government to establish a liquid industrial waste and hazardous waste management system for the province. One of the first tasks of the Corporation was to examine the possibility of constructing a treatment and disposal facility at South Cayuga in the Regional Municipality of Haldimand-Norfolk. Preliminary hydrogeological studies of the site revealed that it had several short-comings and the Board of Directors of OWMC voted unanimously to reject the site in November 1981.

Following the rejection of the South Cayuga site, OWMC developed a corporate plan which incorporated:

- The need to design and build a waste treatment and disposal system to manage safely liquid industrial waste and hazardous waste not presently receiving adequate treatment and disposal in Ontario.
- The need to assist Ontario industries in identifying additional, practical ways to reduce and/or recycle liquid industrial waste and hazardous waste.
- The need to consult with the public on the nature and scope of the industrial waste problem and how it can be remedied.

Before a treatment and disposal facility is built, detailed proposals must be presented to an independent Hearing Panel appointed by the Ontario Government, and public hearings will be held.

OWMC is not a regulatory agency, nor is it responsible for treating and disposing of domestic or radioactive wastes.

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1.0 INTRODUCTION AND BACKGROUND

This study has been undertaken for the Ontario Waste Management Corporation (OWMC) with four major objectives:

1. To assemble data on what steps are already being undertaken by Ontario industry to reduce the quantity of waste requiring treatment and disposal.

2. To assess, in qualitative terms, the impact waste reduction initiatives would have on the quantity and nature of waste requiring treatment and disposal facilities in the Province of Ontario.

3. To survey other jurisdictions to ascertain what role organizations, similar in structure and mandate to OWMC, are playing to encourage waste reduction.

4. To suggest potentially useful roles which OWMC might consider assuming to encourage waste reduction in Ontario.

When the Ontario Waste Management Corporation was established in 1981, it was given a parcel of land in South Cayuga to examine as a possible location for a waste treatment and disposal site. In the eyes of much of the general public and industry in Ontario, OWMC is still associated solely with the establishment of a waste treatment and disposal site.

Bill 90(1), "An Act to establish the Ontario Waste Management Corporation" to some extent reinforces that view. The objectives of OWMC are stated as:

> "(a) to research, develop, establish, operate and maintain facilities for the transmission, reception, collection, examination, storage, treatment and disposal of wastes including sewage; and
>
> (b) to perform such other duties as may be assigned to it under this or any other Act."

The intent behind the establishment of OWMC, however, did include waste reduction as an objective. In a Statement of Policy(2) to the Ontario Legislature on November 25, 1980, Dr. H. C. Parrott, the then Minister of the Environment, described the proposed Ontario Waste Management Corporation. In this Statement, he addressed the subject of waste reduction:

> "The site will be operated on a break-even basis. The user fees will act as an incentive to encourage industry to reduce, recycle or re-use their wastes. The board (of the Corporation) will also investigate other ways to reduce waste volumes and encourage waste exchange programs."

The call to examine waste reduction, reuse and recycle as alternatives to waste treatment and disposal has come from groups such as Pollution Probe(3) and The Canadian Chemical Producers' Association(4).

Pollution Probe's 1981 recommendations to OWMC were as follows(3):

> "It is recommended that the Crown Corporation:
>
> 1. Allocate a significant portion of their budget to assist the fledgling field of waste reduction and recovery.
>
> 2. Create a Hazardous Waste Reduction and Recovery Institute or similar body. Functions of this body should include:
>
>   (a) The registering of 'zero waste technologies' by process description, industry type, company name, address and contact person.
>
>   (b) Information transfer among businesses, particularly between small companies that share similar pollution abatement problems.
>
>   We suggest that a toll-free number linked to information officers be made accessible to people across Canada and possibly throughout the United States.

It is imperative that the information transfer service be accessible not only to the business community but also to workers, the general public and government.

(c) Development and updating of an expert's list which business, government and the public may contact with respect to implementing 'zero waste technologies'.

(d) On-site visits to small businesses requiring assistance in pollution prevention.

3. Allocate funds for research into 'zero waste technology'.

4. Organize and sponsor a conference on 'zero waste technologies'.

5. In the interim, function as a waste broker by 'finding new homes' for wastes otherwise earmarked for landfill at the proposed centralized disposal facility.

   In the long term, it is anticipated that private enterprise will find it more satisfactory to transfer its wastes directly for re-use by another industry.

6. Study economic and legislative incentives that may be applied to encourage waste reduction and recovery. Study also the disincentives that may be applied to discourage unnecessary destruction and landfilling of wastes.

7. Place a surcharge or special tax on hazardous wastes that are landfilled or destroyed. The revenue generated in this manner could be used to fund and implement 'zero waste technologies'."

The Canadian Chemical Producers' Association has published a policy paper on hazardous waste handling and disposal(4). This paper represents the position of all of the major chemical companies in Canada. In this paper, they outline four questions which should be considered by companies generating industrial waste:

> "Four basic questions can be asked about any industrial waste material:
>
> - Can it be eliminated at its source?
> - Can it be recycled, either by the generator or another expert party?
> - If it is hazardous, can it be converted into a non-hazardous form?
> - If it must be disposed of, how can it be most effectively and efficiently processed?
>
> No manufacturer wants to generate hazardous wastes. Industrial wastes are the unwanted but necessary by-products of the manufacturing processes that are intrinsic to contemporary life. Today, much industrial waste is economically recycled. This trend will undoubtedly continue and will be fostered by further innovations in research and technology. Even so, however great the progress in waste reduction and recycling, hazardous wastes will inevitably be produced in some form. Their safe disposal will therefore remain an important objective within the public policy elements that directly affect Canadian manufacturing industries."

These two published policy positions from what might traditionally be regarded as the two extremes of the opinion spectrum on environmental matters are remarkably similar in their intent. Both are proponents of "zero waste technology" or eliminating the generation of waste as being the ultimate solution to the problem. Probe offers more specific recommendations to OWMC to whom their brief was addressed.

The Canadian Manufacturers Association (CMA) in a submission to OWMC offered what first appears to be a dissenting opinion(5):

> "Increased disposal costs resulting from use of the site will be the most efficient way to encourage recycling and reuse. In this context we are somewhat concerned that OWMC is spending over $100,000 at this time to study how it can promote recycling. The first approach should be to establish this site, set disposal costs and let the pricing mechanism of the market place promote recycling.
>
> We also must face the fact that recycling will never be anywhere near a complete solution. A fact of industrial life is the need for waste treatment and disposal. Clearly we do not have all the required facilities to meet today's needs, much less the needs of an expanding manufacturing sector that Canadians are counting on to provide jobs for tomorrow. All agree that finding a site for a safe disposal facility is necessary and CMA thinks the OWMC approach of involving the public throughout its decision making process will help solve the key problems - locating a site and obtaining approvals."

What the CMA is saying, in essence, is that, in their opinion, the most effective role for OWMC to encourage recycling is through discouraging waste treatment and disposal by its pricing policies.

This "implicit" role for OWMC in the encouragement of waste reduction is certainly a very important one, and may indeed prove to be the most effective approach. The CMA submission recognizes the desirability of reduction as a preferable option to treatment and disposal. They also caution that recycling may only be part of the solution, and that effective treatment and disposal facilities must be provided.

These three examples of public and industry opinion largely agree that the principle of waste abatement, reduction, reuse and recycle is a preferred waste management approach. The two submissions to OWMC differ on their recommendations for roles which OWMC might consider to encourage waste reduction.

In an earlier report to OWMC on Waste Reduction(6), a hierarchy of approaches to waste management was discussed:

- Waste abatement, non-waste or zero discharge technologies
- Waste reduction
- Waste reuse
- Waste refining for recycle
- Waste treatment and destruction
- Waste disposal.

These are listed in descending order of desirability from an environmental and resource conservation point of view. There are many factors which influence which of these waste management approaches is most appropriate for a specific industrial waste problem. Most of these factors can be expressed in economic terms and a responsible industrialist will select the least cost, legal method of solving a waste management problem.

The choice of method of approach changes over time and with the existing economic situation. There are three major economic trends which are influencing industry to consider moving up the hierarchy of approaches to waste management. These are (6):

> "The cost of some raw material is rapidly escalating, and, in fact, the continuing availability of at least some of these resources is quite uncertain.
>
> The cost of energy to process these raw materials into usable commodities is increasing at an even greater rate.
>
> The cost of proper waste treatment and disposal is, for the most part, also growing at a rate higher than general inflation."

Waste Abatement

For companies with existing process plants it is probable that they will initially examine waste reduction, reuse and recycle opportunities. Waste abatement (i.e. the substitution of low waste technology) may be more difficult to justify where a substantial capital investment has been made in the existing equipment. Waste abatement is an attractive option for new plants or plant expansion or replacement. It may also be economically attractive for existing plants.

Waste Reduction

The least expensive first step for existing process plants to consider is waste reduction. This involves a very careful survey of waste generation to determine whether simple changes could be implemented to reduce the volume of waste being generated, or to reduce the complexity of the nature of the waste.

In many older plants, all liquid wastes are collected in a common drainage system. This may result in quite concentrated wastes mixing with rinse waters and even cooling waters to give a very dilute waste stream, which may still contain contaminants, above the acceptable level for local sewer use by-laws. Thus, an obvious first step in waste reduction would be to collect that concentrated waste separately. Then, the concentrated waste can be examined for its potential value for reuse or recycle. Even if no reuse or recycle options are economically viable, the volume of waste requiring treatment and disposal is reduced.

Avoidance of mixing of waste streams should also be examined for two or more concentrated waste streams. For example, consider a plant which generates both chlorinated and non-chlorinated waste solvents. If these wastes are stored in separate vessels, they can be recovered quite easily using simple distillation techniques. If mixed together,the recovery process becomes much more complex, and the costs for recovery may not be justified by the value of the recovered products. Even if recovery is not technically or economically feasible, waste treatment and disposal costs for this mixed waste will be much higher than they need to be. Incineration, which is the treatment method of choice for organic liquid wastes which are not recycled, is more expensive for chlorinated materials than non-chlorinated. This is due: (a) to the higher temperatures which are required to ensure that highly toxic products of combustion are not formed; and (b) to the more sophisticated gas cleaning systems which must be employed to resist the highly corrosive nature of the acid gases formed during incineration. Thus, if a company produces one drum of chlorinated solvent waste and three drums of non-chlorinated solvent waste, and these are all mixed together, the charge for the disposal of four drums of chlorinated waste, will be higher.

This examination of present practices, or "waste survey", is the first step in waste reduction. Improvements can often be made with a minimum of capital investment, and in many cases, a minimum of extra operating costs or additional operating difficulties are incurred.

Waste Reuse

Having reduced the wastes to a minimum volume and kept different types of wastes separate, the next step is to examine opportunities for reuse of those wastes. The obvious first place to look for reuse opportunities is within the plant that generates the waste. This minimizes legal problems, transporation costs and other difficulties associated with transferring of waste from one company to another. While none of these problems are insurmountable, they do have to be addressed when matching a waste generator with a potential waste user. Two examples of in-plant reuse of waste are as follows:

- In most thermoplastic fabricators' operations, any trim, (known as "home scrap") is returned to be remelted and reprocessed.

- By-product gas, from the production of coke from coal, in the steel industry, is used as a fuel in the blast furnace.

If, after examining the opportunities for reuse within the plant generating waste, no suitable opportunity is identified, reuse opportunities can be sought in other plants. This, in general, is more difficult than the internal reuse situation. The barriers to reuse include the cost of haul, ownership and legal considerations, plus assurances of quality and availability. Another barrier to more widespread reuse of wastes in other plants is the lack of knowledge of the availability of these wastes on the part of the potential reuser, or of the needs of potential reusers by the waste generators. To serve this information transfer need, central information clearing houses called waste exchanges have been established in many countries.

In Canada, the Canadian Waste Materials Exchange (CWME) publishes a bulletin six times each year in which generators list waste streams which are available, and potential users can list waste streams which they are seeking as substitute raw materials. The bulletin is sent to several thousand industrial participants. Any potential users or potential suppliers of the listed wastes are put into contact with each other and they may negotiate a satisfactory arrangement. The CWME is a "passive" exchange, dealing only in information and acting more or less as a "marriage broker". Other waste exchanges may actually participate in the negotiations and may take legal possession of the waste stream prior to reselling to a user(6, 7).

Two examples of waste reuse by others through waste materials exchanges are as follows:

- Use of by-product phenols from a refinery in the production of phenolic thermoset plastic resins.

- Use of solvents from circuit board cleaning directly by paint manufacturers.

Waste Refining For Recycle

Some waste streams cannot be reused directly without some upgrading. This upgrading is termed waste reclamation or recycle. It is slightly less desirable than waste reuse, inasmuch as the terms upgrading or reclamation imply that a residual waste will result from such processes. This can range from a very minor proportion in the case of solvent reclamation, to almost 100% in the case of metals recovery from flyash or sludge incinerator ash. Some recycle operations may be undertaken in-house, directly by the industry generating the waste. Monoethanolamine and diethanolomine, which are solvents utilized by the petroleum industry to purify "sour gases", (i.e. fuel gases which contain hydrogen sulphide) are regenerated on site. Several companies using solvents have installed simple solvent distillation equipment. One such unit distributed in Canada utilizes a 45-gallon drum as the boiler. Dirty solvents are collected in the drum. The drum is then inserted into the unit, a heater clamped around the drum, and the vapourized solvent is passed to a condenser and is condensed into a receiving drum(8).

As well as these in-plant approaches to recycling, there is a well established recycling industry within the Province of Ontario, as discussed in Chapter 6 of this report. Solvents, waste oils, oily wastepaper, pickle acid, photographic chemicals, and other precious metal sludges, are all reclaimed either on a "toll" basis (i.e. the reclaimer charges a clean-up fee and returns the purified material to the generator), or the reclaimer takes possession of the waste and finds a market for the reclaimed material.

If waste abatement, reduction, reuse or recycle are not technically or economically feasible for a specific waste stream, then these streams should be directed to a safe treatment and disposal facility. One of the purposes of this study is to examine the barriers to increasing the efficacy and desirability of waste reduction. Then, from this identification of barriers, to develop suggestions for useful roles for OWMC to consider to promote waste reduction in the Province of Ontario.

Many of the approaches to waste abatement, reduction, reuse and recycle are industry, and even individual plant, specific. Therefore, during our telephone survey of industry to ascertain what waste reduction initiatives they have either put in place or are considering, we posed the following question: "What activities do you feel that OWMC could undertake to help you to reduce or reuse some of your waste streams?" A similar question, though worded differently, was directed to the recyclers during the study. The information gathered is discussed in Chapter 8 of this report.

1.1 REFERENCES

1. Bill 90. An Act to Establish the Ontario Waste Management Corporation, 1st Session, 32nd Legislature, Ontario 30 Elizabeth II, 1981.
2. Parrott, H. C. "Re: Ontario Waste Management Corporation (Statement of Policy)" Statement to the Legislature Ontario, Toronto, November 25, 1980.
3. Pollution Probe. "Recommendations to Ontario Waste Management Corporation w.r.t. Hazardous Waste Reduction and Recovery", June 18, 1981, Toronto.
4. The Canadian Chemical Producers' Association Policy Paper on "Hazardous Waste Handling and Disposal", Ottawa, March, 1982.
5. The Canadian Manufacturers Association. Submission to OWMC on "Phase 1 Report and Recommendations", October 21, 1982.
6. Proctor & Redfern Limited, Weston Designers - Consultants, and Ontario Research Foundation (1982). Waste Reduction Background Paper prepared for Ontario Waste Management Corporation, Toronto, Ontario.
7. Laughlin, R. G. W., and Golomb, A. "The Methodology for the Operation of a Waste Materials Exchange in Canada", Environment Canada Report EPS 3-EC-77-8, March, 1977.
8. Canadian Lukens, "Solvent Recovery System" sales brochure.

2.0 INDUSTRY SURVEY

2.1 SURVEY DESIGN: STUDY APPROACH

The industry survey was designed to cover three major industry sectors or Standard Industrial Classifications (SIC). These sectors were:

SIC 33	Primary Metals Industry
SIC 34	Fabricated Metal Parts Industry
SIC 28	Chemical Manufacturing Industry

These three manufacturing industry sectors were identified in an earlier study of waste quantities (1) to generate 70% of special waste in the Province of Ontario. They were further shown to generate all of the major special waste types in the Province. A survey of these industry sectors was considered a representative view of waste reduction practices and perceived needs for the stimulation of waste reduction in Ontario.

For each of the three industry sectors, approximately 100 to 110 companies were selected. Selection of companies was made using the lists generated during the Waste Quantities Study(1) and other available data such as Scott's Index Ontario Manufacturers(2) and Dun and Bradstreet's Directory(3).

Selections were made with the following objectives:

- To cover as many of the industry sub-sectors within the sector as possible.

- To include a range of sizes of companies in terms of employment data, from very small, 5 employees, to some of the largest in the sector.

- To include companies from different geographic locations throughout Ontario.

These objectives were applied with some flexibility. For example, if an industry sub-sector (4 digit SIC) within the sector was identified by the Waste Quantities Study to not generate special waste, this sub-sector was not surveyed, or perhaps a single firm was contacted. For those sub-sectors which appeared from the Waste Quantities Study to generate the most waste, a greater number of firms were contacted.

A package of material was sent out to each of the companies on the list, which served to introduce OWMC, and to outline the purpose of the study. A copy of this material is included as Appendix A.

A week to ten days after the material had been sent out, attempts were made to contact all companies by telephone. Making contact with the right person within the company proved to be quite difficult in many cases. The eventual "success rate" was about 70% for all three industry sectors. Several companies on the list were out of business. A number of companies absolutely refused to participate in the survey; others declined to take part on the basis that they felt that they had no waste, and, therefore, had no information which would be of use to the project team. A few companies could just not be contacted after four weeks of attempts.

For those companies willing to participate in the survey, the questionnaire (Appendix A) was used to record information from the telephone interview. The information which was generated from the interviews with these companies was extremely useful and is discussed in detail in Sections 3.0 to 5.0.

These three report sections detail the results of the survey and of a parallel literature study of the industry, its major wastes, and approaches to waste reduction. They are organized into sections covering:

- An Industry Overview

- Major Processes, Waste and Reduction Techniques

- Approaches in Waste Reduction in Ontario and Current Waste Reduction Disposal Practices

- Potential Roles for OWMC to Encourage Waste Reduction

- Trends in Waste Quantities and Qualities

The Chemical Manufacturing and Fabricated Metals Parts sections discuss these for the industry as a whole. The Primary Metals sector, where there is a complex internal recycling of by-products particularly in the Iron and Steel group it was found to be more convenient to consider these points under four industry subsectors.

Information on waste characteristics and generation, and waste reduction practices by industry is described in Sections 3.0 to 5.0 "as reported" by company representatives during the telephone interviews. In all cases an estimate was requested on the accuracy of the reported data, and whether the respondent company was typical within an industrial sector.

The aggregate of responses outlined in the following sections may not be representative of all firms within a particular industrial sector. Rather, the information is intended to provide a general overview of waste reduction practices in Ontario, and current fates of wastes typically generated by these industries.

2.2 REFERENCES

1. Proctor & Redfern Limited, Weston Designers-Consultants, and Ontario Research Foundation (1982) "Waste Quantities Study", prepared for Ontario Waste Management Corporation.

2. Scott's Industrial Directory Ontario Manufacturers, 13th Edition. Scott's Industrial Directories, (1981).

3. Dun and Bradstreet Ltd., "Canadian Key Business Directory (1982)".

3.0 PRIMARY METALS INDUSTRY (SIC 33)

3.1 OVERVIEW

This Standard Industrial Classification group includes industries engaged in the smelting and refining of ferrous and non-ferrous metals from ore, pig, or scrap; in the rolling, drawing and alloying of ferrous and non-ferrous metals; in the manufacture of castings and other basic products of ferrous and non-ferrous metals; and in the manufacture of nails, spikes and insulated wire and cable. It also includes facilities engaged in the production of (metallurgical) coke.

The Primary Metals Industry is a diverse group of industries generating a wide range of waste types and manufacturing many different kinds of products. Within this group there are four general groups of industries which, for the purposes of this report, have been categorized on the basis of waste generation and production similarities. These are:

- Iron and Steel Works
- Metal Casting and Foundries
- Primary and Secondary Smelting and Refining
- Other Primary Metals Industries

The SIC 33 category can also be subdivided into 4-digit SIC designations. These are listed in Table 3-1 along with a brief description and the number of plants in Ontario assigned these 4-digit SIC numbers. It can also be noted from Table 3-1 that SIC 33 plants are concentrated predominantly in and around Toronto, Hamilton, Guelph, Cambridge and St. Catharines, with other regional centres in Sudbury, Sault Ste Marie and Timmins.

Scott's Industrial Directory, from which the table is drawn, lists plants that are involved in more than 1 four digit SIC activity. Thus some double counting of plants is included in this list.

Plants belonging to SIC 33 in Ontario range from small operations having one employee to some of the country's largest facilities. For example, Canada ranks as the 12th largest steel producer in the world, and the country's three largest steel companies operate primarily in Ontario.

TABLE 3-1
LISTING OF SIC 33 FACILITIES IN ONTARIO

SIC	Description	Number of listings	Predominant Locations*
Iron and Steelworks			
3312	Blast furnaces, steel works and rolling mills	37	Hamilton, Sault Ste Marie
3317	Steel pipes and tubes	19	Toronto
Metal Casting and Foundries			
3321	Gray iron foundries	79	Toronto, Hamilton, Cambridge, St. Catharines
3322	Malleable iron foundries	13	Guelph, Cambridge
3324	Steel investment foundries	5	
3325	Steel foundries (nec.)	27	Toronto, Hamilton, Welland
3361	Aluminum foundries (castings)	107	Toronto, St. Catharines, Hamilton, Cambridge
3362	Brass, bronze, copper, copper based alloy foundries (castings)	75	Toronto, Guelph St. Catharines
3369	Nonferrous foundries (castings) (nec.)	75	Toronto, Guelph, Windsor
Primary and Secondary Smelting and Refining			
3331	Primary smelting and refining of copper	7	
3332	Primary smelting and refining of lead	2	
3333	Primary smelting and refining of zinc	4	
3334	Primary production of aluminum	3	
3339	Primary smelting and refining of non-ferrous metal	17	Sudbury, Toronto, Timmins
3341	Secondary smelting and refining of nonferrous metal	24	Toronto

TABLE 3-1 cont.

SIC	Description	Number of listings	Predominant Locations*
Other Primary Metals Industries			
3313	Electrometallurgical products	6	
3315	Steel wire drawing and steel nails and spikes	17	Toronto
3316	Cold rolled sheet steel strips and bars	16	Toronto, Hamilton
3351	Rolling, drawing and extruding of copper	11	Toronto, Hamilton
3353	Aluminum sheet, plate and foil	3	
3354	Aluminum extruded products	21	Toronto
3355	Aluminum rolling and drawing (nec.)	3	
3356	Rolling, drawing and extruding of nonferrous metals (except copper and aluminum)	25	Toronto
3357	Drawing and insulating of nonferrous wire	36	Toronto
3398	Metal heat treating	45	Toronto
3399	Primary metal products (nec.)	16	Toronto

Source: Scott's Industrial Directory Ontario Manufacturers (1981)

* Indicated only when category has 10 or more entries.

The current economic recession has effected SIC 33 industries, and as a result, most plants are operating well below capacity and others have been virtually shut down for months. By the end of 1982, steel production was at its lowest level in 10 years. The industry was operated at 45 percent of capacity with 25 percent of the work force on indefinite layoff. SIC 33 industries are closely tied to the manufacture of motor vehicles, farm machinery, railroad locomotives, cars, household appliances, etc.

Due to the diversity, size and economic importance of the industries comprising this SIC category, numerous trade and technical associations have been established to serve the needs and interests of member companies. Table 3-2 lists the leading U.S. based associations. Because of the close economic and technical ties between the U.S. and Canada, many Ontario firms are also members of one or more of these associations or are affiliated with an Ontario/Canadian chapter.

These associations provided useful information in the study of the Primary Metals industry. Many are active in the environmental field and publish manuals, directories and books concerned specifically with pollution control and reuse/recycle practices. They are also a good source of information on production and employment statistics for their industry sectors.

Table 3-3 lists the six leading Canadian/Ontario based associations involved with SIC 33. Five of the six were contacted during the study. The Canadian Copper and Brass Development Association, the Canadian Die Casters Association and the Ontario Chapter of the American Foundrymen's Society were helpful in providing both contacts and a commitment to bring the activities of OWMC to the attention of their members. The Canadian Institute of Mining and Metallurgy and the Canadian Forgings Association both reported that environmental matters were dealt with by individual firms and were not part of the associations activities.

A number of technical and trade periodicals dealing with all facets of the primary metals industry are also available. Table 3-4 lists some of the leading journals originating from the United States and England. Some of these are published by the associations appearing in Table 3-2, while others are brought out by commercial publishers. Pertinent Canadian publications include Canadian Mining Journal, CIM Bulletin, Canadian Copper, Canadian Machinery & Metalworking.

TABLE 3-2

UNITED STATES-BASED TECHNICAL/TRADE ASSOCIATIONS

The Aluminum Association
The Aluminum Recycling Association
American Die Casting Institute, Inc.
American Hot Dip Galvanizers Association
American Iron and Steel Institute
American Electroplaters' Society
American Foundrymen's Society
American Society for Metals
Cadmium Association
Cast Bronze Institute Inc.
Cast Metals Federation
Ductile Iron Society
Institute Scrap Iron & Steel, Inc.
International Copper Research Association, Inc.
International Lead Zinc Research Organization, Inc.
Metal Properties Council
Metal Research and Development Foundation
Metal Treating Institute
National Association of Metal Finishers
National Slag Association
Non-Ferrous Founders Society
The Silver Institute
Society of Die Casting Engineers, Inc.
Steel Founders' Society of America
Tin Research Institute, Inc.
Wire Association International
Zinc Institute Inc.

TABLE 3-3

CANADIAN-BASED TECHNICAL/TRADE ASSOCIATIONS

American Foundrymen's Society
Ontario Chapter
c/o Mr. Ed Golz
Turboblast Inc.
749 Warden Avenue
Toronto, Ontario

Canadian Copper & Brass Development Association
55 York Street
Suite 1612
Toronto, Ontario
M5J 1R7

Canadian Die Casters Association
1 Yonge Street
Suite 1400
Toronto, Ontario
M5E 1J9

Canadian Forgings Association
1 Yonge Street
Suite 1400
Toronto, Ontario
M5E 1J9

Canadian Foundry Association
P. O. Box 2270
72 Mississauga Street East
Orillia, Ontario
L3V 6S7

Canadian Institute of Mining and Metallurgy
1130 Sherbrooke West
Suite 400
Montreal, Quebec
H3A 2M8

TABLE 3-4
SELECTED LIST OF UNITED STATES AND BRITISH JOURNALS RELEVANT TO SIC 33

Engineering Mining Journal
Foundry M & T
International Metallurgical Reviews
Industrial Finishing
Iron and Steel Engineer
Journal of Metals
Metal Finishing
Metal Progress
Modern Casting
Plating and Surface Finishing
Steel Times
Steel Times International
33 Metal Producing
Transactions of the American Foundrymen's Society
Wire
Wire International

Because of the large quantities of liquid and solid waste generated by the primary metals industry and since a considerable fraction of the wastes have been designated as hazardous or are considered potentially hazardous, environmental regulatory agencies in both the United States and Canada, particularly the United States Environmental Protection Agency (US EPA) have devoted considerable attention to these industries. In addition to enacting and enforcing regulations for the discharge of liquid wastes and the disposal of solid wastes, these agencies are also active in quantifying and characterizing the wastes generated, devising reliable analytical techniques and assessing applicable treatment/disposal technologies. Publications released by the U.S. EPA during the past few years are perhaps the most comprehensive source of information on waste generation and pollution control in the primary metals sector(49).

In order to gain a more thorough overview of the waste management practices of this industrial grouping in Ontario, Ministry of the Environment (MOE) offices in Toronto and Welland were contacted. MOE supplied some useful information and contacts for the study.

Many chemical suppliers to the primary metal industry also tend to be active in environmental affairs; i.e., treatment/disposal as well as reuse/recycle practices, particularly as it effects their products. For example, Ashland Chemical Co., the leading supplier of foundry sand binders, was helpful in providing general brochures, reprints, etc. describing the properties of the various binders and the disposal of spent foundry sand.

E. F. Houghton & Co. is one of the leading suppliers of metal cleaning formulation. Although the company does publish brochures describing recommended treatment/disposal methods for the wastes generated through the use of the company's products, the firm only becomes involved in reuse/recycle possibilities if very large quantities are involved.

3.2 IRON AND STEEL WORKS

Integrated steel complexes (Fig. 3.1) utilize huge volumes of process water and generate large quantities of wastewater and solid waste. A typical integrated steel plant requires 85 to 135 cubic metres of water per tonne of steel produced(25). About 20 to 50% of this water comes into direct contact with process gases and/or products while the remainder is mainly non-contact cooling water.

Cooling waters are used in numerous processes such as coke quenching, in blast furnaces and in continuous casting, and rolling of steel. Water usage for both cooling and processing occurs in the cleaning of blast furnace gases, slag quenching, descaling during rolling operations and rinsing in the pickling lines.

Solid waste generated by an iron and steel plant include: blast furnace and steelmaking slags, coal washery shale and sludge, coke plant residues, refractory rubble, iron-bearing dust and sludge and miscellaneous discards.

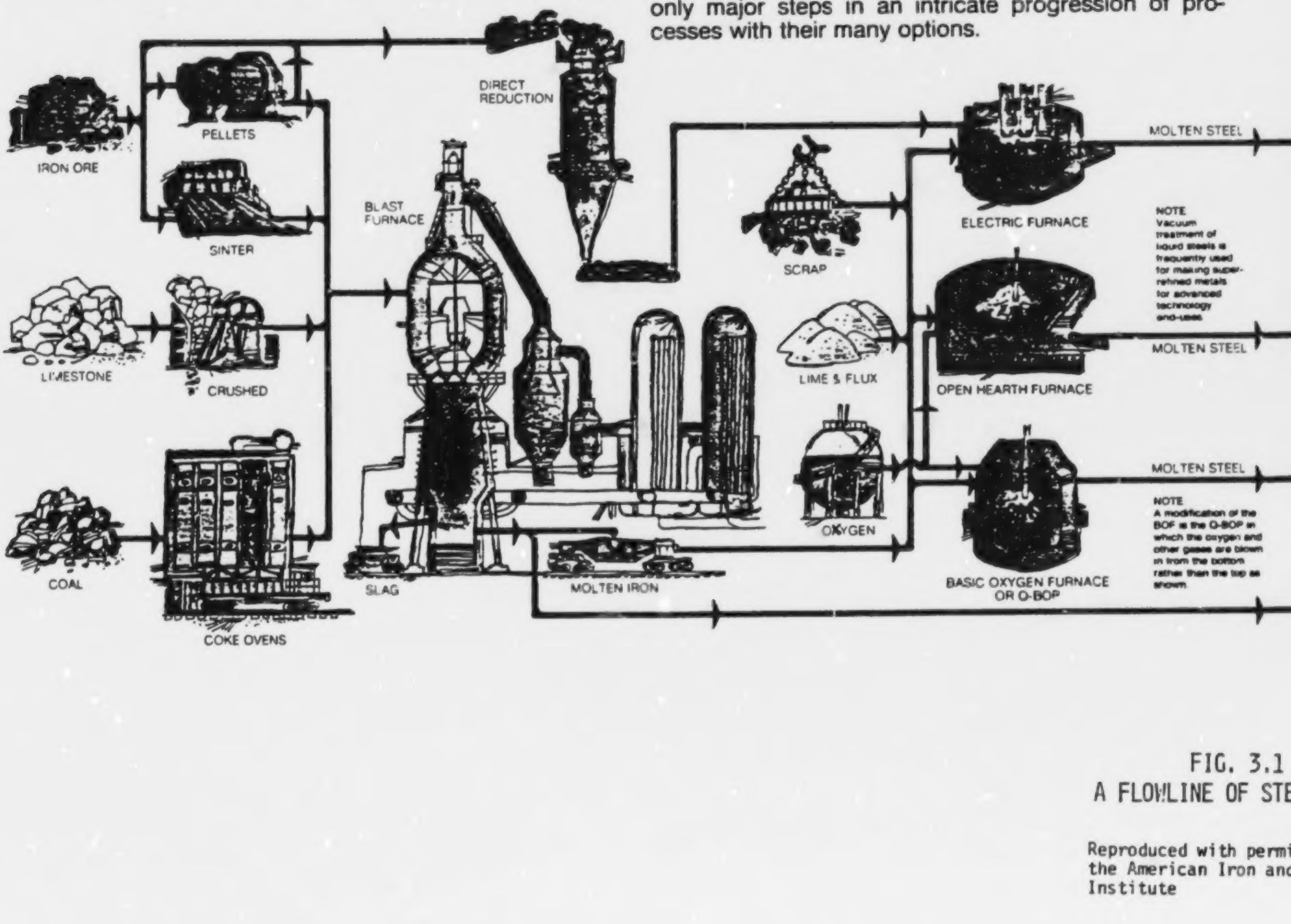
It is difficult to adequately identify and describe all sources of pollution in an operation as complex as a steel mill or to describe all the various techniques employed for wastewater treatment, solid waste disposal and reuse/recycle, without extensive study. Further information can be obtained from several publications prepared during the past few years (19, 26, 27, 29, 37, 49).

The following discussion has been divided into three parts; the first describes the sources, volumes, characteristics and treatment of the major wastewater streams, the second covers the sources, quantities and disposal of the chief solid wastes while the third section focuses on the most important reuse/recycle practices in the industry. The discussion is confined to wastes which arise directly or indirectly from the processes depicted in Figure 3-1. Wastes from utility operations and special wastes such as PCBs are not addressed in any detail.

Source: Iron and Steel Engineer, August, 1982.

a flowline of steelmaking

From iron ore, limestone and coal in the earth's crust to space-age steels -- this fundamental flowline shows only major steps in an intricate progression of processes with their many options.

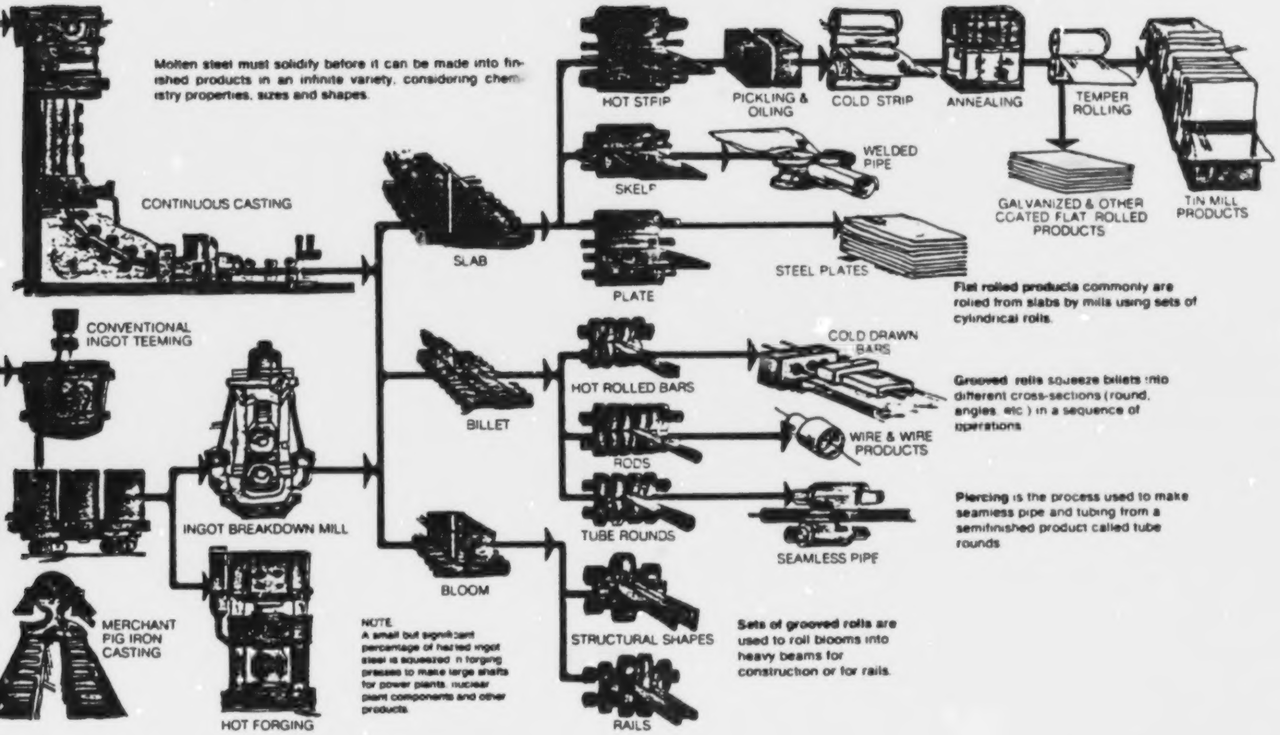

IRON ORE
PELLETS
SINTER
LIMESTONE
CRUSHED
COAL
COKE OVENS
DIRECT REDUCTION
BLAST FURNACE
SLAG
MOLTEN IRON
SCRAP
LIME & FLUX
OXYGEN
ELECTRIC FURNACE
OPEN HEARTH FURNACE
BASIC OXYGEN FURNACE OR O-BOP
MOLTEN STEEL
MOLTEN STEEL
MOLTEN STEEL

NOTE
Vacuum treatment of liquid steels is frequently used for making super-refined metals for advanced technology end-uses.

NOTE
A modification of the BOF is the O-BOP in which the oxygen and other gases are blown in from the bottom rather than the top as shown.

FIG. 3.1
A FLOWLINE OF STE

Reproduced with permi
the American Iron and
Institute


CONTINUOUS CASTING
CONVENTIONAL INGOT TEEMING
MERCHANT PIG IRON CASTING
INGOT BREAKDOWN MILL
HOT FORGING
SLAB
BILLET
BLOOM
HOT STRIP
PICKLING & OILING
COLD STRIP
ANNEALING
TEMPER ROLLING
SKELP
WELDED PIPE
GALVANIZED & OTHER COATED FLAT ROLLED PRODUCTS
TIN MILL PRODUCTS
PLATE
STEEL PLATES
HOT ROLLED BARS
COLD DRAWN BARS
RODS
WIRE & WIRE PRODUCTS
TUBE ROUNDS
SEAMLESS PIPE
STRUCTURAL SHAPES
RAILS

Molten steel must solidify before it can be made into finished products in an infinite variety, considering chemistry properties, sizes and shapes.

NOTE
A small but significant percentage of heated ingot steel is squeezed in forging presses to make large shafts for power plants, nuclear plant components and other products.

Flat rolled products commonly are rolled from slabs by mills using sets of cylindrical rolls.

Grooved rolls squeeze billets into different cross-sections (round, angles, etc.) in a sequence of operations.

Piercing is the process used to make seamless pipe and tubing from a semifinished product called tube rounds.

Sets of grooved rolls are used to roll blooms into heavy beams for construction or for rails.

LMAKING

sion of
Steel

The physical state of many steel industry wastes is not clearly delineated. This is especially true for the variety of sludges generated. Consequently, a particular waste may be categorized as a liquid waste in one publication while it may be referred to as a sludge or solid waste in another publication.

3.2.1 Major Processes, Waste Streams and Reduction Techniques

The sequence of steel making operations as depicted in Figure 3-1 are divided into six distinct manufacturing processes as given in Table 3-5(7), and discussed below.

1. Coke Manufacturing

Two types of processes may be employed for coking; however, approximately 99% of metallurgical coke is obtained by the by-product process. In addition to coke, this process yields products such as coke oven gas, coal tar, crude and refined light oils, ammonium sulphate, anhydrous ammonia, ammonia liquor and naphthalene. All of these "wastes" have a market value.

Approximately 700 kg of coke, 42 litres of waters, 42 litres of tar, 5.5 kg. of ammonium sulphate and 12.5 litres of light oil are generated from each tonne of coal along with about 70,000 m^3 of fuel gas, all of which is used or sold(1).

According to various publications, an average of 630 litres of wastewater are generated per tonne of coke produced(1). However, this estimate can vary substantially from plant to plant.

Major wastewaters generated from the by-product coking process are the ammonia still waste, coke quenching effluent, indirect cooling water from coolers and still condensers, light oil recovery wastes, and final cooler water overflow.

TABLE 3-5
STEEL INDUSTRY MANUFACTURING PROCESSES

1. Coke Manufacturing
2. Sintering
3. Iron Manufacturing
4. Steel Manufacturing
    - Basic oxygen furnace
    - Open hearth
    - Electric furnace
    - Continuous casting
    - Vacuum degassing
5. Hot Forming
    - Blooming mill
    - Slabbing mill
    - Bar mill
    - Hot strip mill
    - Structural mill
    - Billet mill
    - Plate mill
    - Seamless pipe mill
    - Rod mill
    - Buttweld pipe mill
6. Cold Finishing
    - Batch pickling
    - Continuous pickling
    - Cold rolling
    - Electric weld pipe mill
    - Cold drawing
    - Screw and nut mill
    - Nail mill
    - Tin plating
    - Coating and galvanizing

Source: Centi, 1971(7)

Ammonia still waste is the liquor resulting from steam stripping of ammonia from raw ammoniacal liquor. Still wastes may vary in volume from 84 to 460 litres/tonne of dry coal, depending on specific process configurations(7). Type of coke being produced and initial moisture content of the coal also affect waste volumes. The waste is the most complex and highly contaminated stream from coking. Chief contaminants present are phenol, cyanides, thiocyanate, ammonia and oil.

The quality of light oil recovery waste generated is a function of the process. Volumes in general range from 84-100 litres/tonne of dry coal(7). Phenol, cyanides, ammonia and oil are the major waste components.

In coke quenching the incandescent coke is cooled by water sprays to prevent combustion. Coke quenching practices vary substantially from plant to plant; for example, some facilities use water drawn from a river or lake while others utilize coke plant wastewater (e.g., weak ammonia liquor). Blast furnace washwater has also been studied for this application.

Coke quenching requires about 2000 liters/tonne of coke. About 30% of this volume evaporates during quenching. Phenol, cyanides and suspended solids are the main pollutants present in this effluent stream.

Although indirect cooling water is not usually considered a waste, leaks in the process lines may create significant pollution problems.

Approximately 20 litres of liquid effluent per tonne of dry coal carbonized is generated in final gas cooling(7). Highly toxic cyanogen compounds may be present in this waste stream.

Treatment of wastes from coke manufacturing present a formidable problem since the combined stream is very contaminated. Biological treatment, more specifically the activated sludge process, is by far the most widely used method of treatment and satisfactory reductions in phenol, cyanides and BOD are readily attained(1,4,7). Adequate ammonia reduction is often not achieved, however, some novel treatment technologies such as the fluidized-bed biological treatment process, are particularly suited for these wastes. The difficulties involved in treating high ammonia concentration coke plant wastes have been the subject of numerous publications(16, 33).

Although most steel manufacturers own and operate their own biological treatment facilities, coking wastewaters have been successfully treated at sewage treatment plants.

2. Sintering

A relatively new process associated with blast furnaces, sintering takes natural fine iron ores and metallic fines produced from residues of other steel plant processes (e.g., blast furnace flue dust and hot rolling mill scales) and fuses them into pieces large enough to be charged into the blast furnaces.

Sinter operations are typically dusty. Airborne dusts are generated from the cooling, screening and sizing of the sinter. Both wet and dry collection systems are employed for air pollution control.

Typical sinter residues generated vary from 15 to 25 kg. per tonne of sinter produced(36). However, particulates collected are generally recycled back into the sintering process and no significant amounts of wastes are generated by sintering plants.

When the zinc and lead contents of the residues are high, these metals are sometimes removed from the iron-rich matrix by a variety of techniques. At some sites, not only particulates but also SO_2 is removed from the sinter off-gases. Usual end-product of desulphurization is either high purity gypsum or ammonium sulphate crystals, both of which are saleable commodities.

3. Iron Manufacturing

The blast furnace is the workhorse in the production of pig iron (i.e., metallic iron) from ore. Hot gases leaving the top of the blast furnace have fuel value and are commonly used in the blast furnace stoves to preheat the air or for underfiring coke ovens. Prior to use, the gases are cleaned by passing them through air pollution control devices. Water from wet scrubbers along with cooling water constitute the major portion of liquid waste from blast furnaces. Wastewater from gas cleaning and cooling amount to some 18,000 litres/tonne of pig iron(25). Recent advances in waste recycle techniques have enabled almost complete recycle of blast furnace water, attaining blowdowns of 210-420 litres/tonne(34).

In addition to suspended solids, the gas wash water also accumulates various organics and inorganics, including phenol, ammonia and cyanides. A study of blast furnace washwater streams at a British steel complex indicated dissolved solids of 1200 to 1800 mg/l, suspended solids of 40 to 200 mg/l, chlorides of 300 to 400 mg/l, oil of 20 to 200 mg/l in addition to high levels of cyanide, phenols and several heavy metals(19).

Treatment of blast furnace washwater is aimed at reducing suspended solids, phenol and ammonia levels. Sedimentation is employed for the removal of suspended solids while alkaline chlorination is the most widely used technique for the removal of cyanides, phenol and ammonia.

4. Steel Manufacturing

For the conversion of iron to steel, three different furnace types are in use: the Basic Oxygen Furnace (BOF), the electric furnace, and the open hearth furnace. Currently, the BOF accounts for about 50% of steel production in North America and is rapidly replacing the older open hearth furnaces. However, since each process employs the same basic raw materials, the wastes generated from all three are similar.

All three have two possible water discharge sources. The first is non-contact cooling water and the second is the effluent from wet gas treatment systems. Non-contact cooling water picks up only heat.

Vacuum degassing is a technique used to adjust the final chemistry of steel in the period between tapping of the steelmaking furnace and the commitment to either ingot or various steel casting operations. The product is a cleaner steel with improved physical properties. Effluent from vacuum degassing contains mainly iron oxide fumes and carbon monoxide gas. Waste volumes are not large and are treated jointly with other steelmaking effluents.

After steel has been made, the molten metal is tapped from the furnaces into teeming ladles and then transferred to a teeming area or to a continuous casting area. In the teeming area, the molten steel is poured into ingot molds. When solidified, the ingots are placed in soaking pits and afterwards rolled into billets, blooms, or slabs.

However, in continuous casting, billets, blooms and slabs are cast directly from the hot steel, thereby eliminating the need for ingot molds, soaking pits, etc. Developed in Europe and introduced into North America in the 1960s, continuous casting saves more than $10 per tonne of steel over conventional ingot techniques. Moreover, while up to 30% of the steel poured is lost in ingot trimming and mill scale, losses in continuous casting are 10% or less.

The waste stream from continuous casting contains steel scale and some oil from the machinery. Settling is the most common method for removing the scales. Recovered scales can be recycled to the sintering plant.

5. Hot Forming

Hot forming is the further processing of steel ingot usually in a blooming or slabbing mill. Billets, blooms and slabs are sent to the hot strip rolling mills where they are converted into a wide variety of finished or semi-finished products, including bars, rods, tubes, rails, structured shapes, sheets and plates.

The main liquid wastes generated from the hot forming process are scale-bearing waters and cooling waters. Total scale loss is up to 3% of product weight(37).

Large suspended particles can be readily removed by the use of scale pits while oil is removed concurrently by adhering to the settled scales. Oil removal can be improved by employing oil skimming devices.

6. Cold Finishing

Cold finishing processes include pickling; cold rolling, coating (i.e., tin plating, galvanizing, etc.); cold drawing of wire, rod, tubes, etc.; screw and nut manufacturing; nail making; and electric pipe manufacturing.

Pickling is the process whereby oxides and scales formed during the rolling operations are removed by the action of an inorganic acid, usually hydrochloric or sulphuric acid. Sulphuric acid (H_2SO_4) has long been used for pickling while the use of hydrochloric acid (HCl)is relatively recent. More extensive use of HCl has been hampered by its high cost. However, effective regeneration systems developed in recent years have altered the picture considerably. HCl is now considered more economical than H_2SO_4 when employed in conjunction with a regeneration plant.

Depending on the shape and composition of the pickled steel, the quantity of spent acid (i.e., pickle liquor) may range from 30 to 105 litres/tonne of steel product and typically contains 6 to 12% iron in solution as the salt of the pickling acid, 0.5 to 11% free acid; traces of heavy metals, dirt and minor amounts of oil.

In cold drawing a bar, wire or tube is pulled through a die to reduce it to the desired size.

In bar mills, the bars pass through a series of rolls to reduce them to the required thickness and surface finish.

Steel nails are produced in automatic machines that are based on the same principles in all plants. Wires of specific grades are used to make bolts, rivets, screws and the like.

Tin plating can be accomplished by either the electrolytic or the hot dip process. Tin, zinc, nickel, chromium, cadmium, copper, aluminum bronze, silver, gold and lead are the coatings most frequently applied onto steel. Coating operations can be carried out by: electroplating, hot dipping, metal spraying, metal cementation, metal cladding or fusion welding.

Rinse waters from pickling operations may contain significant concentrations of acid and iron salts. As mentioned, spent acid baths contain residues of concentrated acid and iron salts generated in the pickling process.

Effluents from tin plating and other coating operations are characterized by the presence of various heavy metals, cyanides, acids and alkalis.

Spent rolling solutions contain mainly oil and suspended solids as do waters used for direct cooling.

It is difficult to generalize about the volume of wastewaters generated from the various cold finishing operations because of the diverse nature of the processes.

Aside from regeneration, the chief techniques used for the handling of pickle liquor wastes are neutralization and disposal by outside contractors. Neutralization generates a sludge which requires disposal. Sedimentation is most widely employed for the removal of suspended solids while oils are usually separated from the aqueous phase by skimming.

A multitude of processes are available for the treatment of plating wastewaters, including precipitation, alkaline chlorination, ion exchange and reverse osmosis. Metal recovery is also practiced at some sites. Selection of the most technically and economically advantageous process depends on the type of plating wastes involved, capital and operating costs of the treatment/ recovery processes, quantity of residue generated, cost and availability of disposal sites for the residues, and the cost of raw materials vs. value of the recovered materials.

Solid Waste Generation and Disposal

According to a recent publication, approximately 60 million tonnes of solid waste are generated by the U.S. steel industry(18). About 80 to 90% of this quantity is considered non-hazardous and about 60% of these wastes are disposed of by outside sales and/or internal recovery, leaving some 19 million tonnes for disposal.

Table 3-6 summarizes the types and quantities of non-hazardous solid wastes generated by the United States steel industry annually along with their fate. Estimated annual quantities of hazardous solid wastes and their fate are shown in Table 3-7. Although the figures appearing in Tables 3-6 and 3-7 pertain to the U.S. steel industry, the figures in terms of percentages would be expected to be very similar for the Canadian steel industry.

TABLE 3-6

ESTIMATED ANNUAL QUANTITIES OF NON-HAZARDOUS SOLID WASTES GENERATED BY THE U.S. STEEL INDUSTRY

(Based on Raw Steel Production of 114 Million Metric Tons)

Waste	Quantity Generated	Waste Dispositions		Quantity Landfilled
	Thousand Tonnes (dry wgt.)	Percent Recycled/Solid	Percent Disposed	Thousand Tonnes
Slags				
Blast Furnace	20,850	95%	5%	1,040
Basic Oxygen Furnace	10,200	50%	50%	5,100
Electric Furnace	3,000	20%	80%	2,400
Open Hearth Furnace	4,400	25%	75%	3,300
	38,450	69%	31%	11,840
Scales				
Soaking Pit	1,000	-	100%	1,000
Primary Mill	4,600	80%	20%	920
Continuous Casting	100	80%	20%	20
Rolling Mills	700	80%	20%	140
	6,400	67%	33%	2,080
Sludges				
Blast Furnace	1,800	75%	25%	450
Basic Oxygen Furnace[1]	800	25%	75%	600
Rolling Mills	275	-	100%	275
Plating, Galvanizing	100	100%	-	-
	2,975	56%	44%	1,325
Dusts				
Blast Furnace	1,200	85%	15%	200
Basic Oxygen Furnace[2]	400	25%	75%	300
Open Hearth Furnace	250	15%	85%	200
	1,850	55%	45%	700
Miscellaneous				
Fly Ash/Bottom Ash[3]	250	-	100%	250
Rubble	3,400	-	100%	3,400
	3,050	0%	100%	3,650

---

[1] 64% of BOF's utilize wet emission controls, 35% utilize dry controls. Dust in the form of kish will be generated whichever device is utilized.

[2] Since 90% of electric furnaces utilize dry controls, assume dry controls are used solely.

[3] Assume (a) 2.5 million tonnes of coal consumed (b) ash content of coal is 12%. Source: Hansen and Kline, 1980(18)

TABLE 3-7
ESTIMATED ANNUAL QUANTITIES OF HAZARDOUS SOLID WASTES GENERATED BY THE STEEL INDUSTRY

Waste	Quantity Generated	Percent Disposed
Decanter Tank Tar Sludge	65,000 tonnes	55%
Ammonia Still Lime Sludge	870,000 tonnes	85%
Electric Furnace Dust/Sludge	340,000 tonnes	100%
Spent Pickle Liquor	5.6 billion litres	40%
Sludge from Lime Treatment of Spent Pickle Liquor[1]	5 million tonnes	100%
Spent Halogenated Solvents and Recovery Sludges/Still Bottoms	20,000 tonnes	100%

---

[1] Assumes treatment of all spent pickle liquor.

Source: Hansen and Kline, 1980(18).

Below is a more detailed discussion of the chief wastes listed in Tables 3-6 and 3-7

Ammonia still lime sludge is generated at a rate of 0.28 kg/tonne of finished steel product(27). The sludge is characterized by significant concentrations of cyanides, phenol, and oil and greases. Because the sludge leaches significant concentrations of phenol and cyanide, it is considered potentially hazardous.

Approximately 2.3 kg. of decanter tank tar sludge is generated per tonne of steel(27). It is considered a potentially hazardous waste because it has been found to leach significant concentrations of phenol, oil and grease.

The most common disposal method for ammonia still lime sludge and decanter tar sludge is open dumping; a practice that is not acceptable because of the hazardous constituents that readily leach from these wastes(27).

Slag along with dust, from dry air emissions control devices, or sludge, from wet air emission control devices, are the solid wastes from the blast furnace. Slag is generated at a rate of 348 kg/tonne of iron output from the blast furnace or 250 kg/tonne of finished steel(27). According to solubility tests, blast furnace slag does not leach any toxic compounds.

Iron oxide, silica and lime are the chief constituents of dust from dry emissions controls serving blast furnaces. The dust also contains significant concentrations of heavy metals (e.g., Chromium, Copper, Manganese, Nickel Lead and Zinc). However, these metals do not readily leach. Dust is generated at a rate of 16.2 kg/tonne of blast furnace iron output or 11.7 kg/tonne of steel product(27).

Blast furnace slag is largely recovered and used mainly as road ballast or building aggregate. Dust and sludge, both rich in iron, are largely recycled to the sinter plant.

Quantities of slag, dust and sludge from BOF, open hearth furnace and electric furnaces are summarized below:

Solid Waste Generated from Iron and Steel Manufacturing
(kg/tonne of steel output)

	Slag	Dust	Sludge
BOF	145	16.0	17.3
Open Hearth Furnace	243	13.7	(no data)
Electric Furnace	120	12.8	8.7

Source: Leonard et al., 1977(27)

It is evident from the tabulation that slags comprise the largest percentage of the wastes and that the amount of slag from the newer BOF and electric furnaces is about half as much as from the older open hearth. The amount of dust generated is about the same.

Slag from these sources is a dense, hard material composed chiefly of silica, iron and lime. Although all three types of slag contain significant concentrations of heavy metals (e.g., Chromium, Copper, Manganese, Nickel, Lead and Zinc), no significant concentrations were found in the extractant when subjected to leachate studies(27).

Dust from all three furnaces is comprised of iron oxides, silica oxide and lime. The heavy metals detected in the slags are also present in the dusts. According to leachate tests, only electric furnace dust released metals in significant concentrations.

Sludge from the three sources contain chiefly iron oxides, silica oxides and lime. Metals present in slags and dusts have also been found in sludges but only electric furnace sludges have released significant concentrations of metals when subjected to leachate tests.

Slag from BOF open hearth furnace or electric furnace are largely disposed of by open dumping or landfilling although as indicated in Table 3-6, a sizeable fraction is recycled. Most steel processors recover metal values prior to dumping. Dust and sludge from all three types of steelmaking furnaces is chiefly disposed by landfilling although dust and sludge from open hearth furnaces is recycled to the sinter plant.

Landfilling is the most common method in use by the steel industry for the disposal of mill sludges which arise from water pollution control operations. Mill scales which are rich in iron are largely recycled to the sinter plant or the blast furnace for recovery. However, scale from cold rolling mills is usually highly contaminated with oil, thus discouraging recycle, and is usually disposed by landfill.

Management of wastes from pickling operations and of the sludge arising from the treatment of the effluents has been discussed in Section 3.2.3.

Reuse/Recycle Practices

Recycle and recovery of various liquid and solid steel industry wastes have already been described in some detail in the previous sections and it is readily evident that many of the wastes generated by the steel industry are recycled or sold.

The reasons for landfilling and/or storing and not recycling various steel industry residues are(36):

- the fineness of the residue, making it physically difficult to recycle to furnace operations
- difficulties encountered in dewatering fine dust slurries and precipitates
- high tramp element (especially Zinc, Lead and Sulphur) content of the residues

- high oil content of the sludges and scales

- low metal and carbon content of the residues, or the low concentration of other useful material e.g., acid or oil.

Recycling is usually not even considered when the metal or other commercially valuable content of the residue or waste is low.

Blast furnace slag is a waste which has many uses. It has long been an accepted semi-commercial material for road building, cement production, and in the case of high phosphorous ore, a fertilizer base(37). Blast furnace slag is also used as a railroad ballast, in glass for the manufacture of amber bottles, in fiberglas manufacture, as a conditioner for oyster beds and as a conditioner for cranberry bogs.

Slag generated from the BOF has a number of limitations. Because of its free lime content, it is unsuitable for road making and it has no value as raw material in cement or fertilizers(37). Although its composition makes it an acceptable material for charging to the blast furnace in place of limestone and other fluxes, the presence of tramp elements (Lead and Zinc) limits this use.

Although open hearth furnace slag is not utilized as extensively as blast furnace slag, it can be used as agricultural liming material and fertilizer, as railroad ballast, as highway chips, as a soil supplement and conditioner, as highway fill or as an aggregate in the manufacture of bituminous concrete.

High lead and iron content of various iron and steelmaking sludges can be lowered to acceptable levels by the following processes: physical separation; the hydro metallurgical method, the electro-metallurgical method and pyrometallurgical methods(36). Only some of the pyrometallurgical processes (e.g., Waelz process) have been found practical.

Oil from rolling mill effluents is easily removed by various types of skimmers and the recovered oil is reprocessed in the plant as an oil or lubricant, sold to outside firms for reprocessing, used for dust suppression on roads and coal piles, or as a source of fuel. A thorough overview on the management of waste oils and related wastes in the steel industry may be found in a recent United States publication(42).

While most of the scale from rolling operations is recycled or sold, most sludges are dumped or stored (see also Table 3-2). It is the oil content in these residues that limit more extensive recycling since when oils adhering to the residues are volatilized during recycling (e.g., in sintering operations) they can cause fires and the escaping oil vapors, or their combustion products, create air pollution.

Generation of pickling residues can be minimized if hydrochloric acid is regenerated and the sulphuric acid recovered, and commercially valuable by-products (e.g., iron oxide, iron sulphate, iron chloride) are produced instead of wastes. Both sulphuric acid recovery and hydrochloric acid regeneration techniques are well established. However, the technology for the recycling of some mixed acids is just emerging. Details about the technology and economics of spent acid reprocessing have been the subject of numerous publications(3, 22, 31, 39).

Iron oxide (Fe_2O_3) obtained from the regeneration of spent acids can be utilized in the manufacture of pigments, ferrite and magnetic tapes, fertilizers, animal feeds and catalysts. currently iron oxide is used primarily in the manufacture of coloured pigments and magnetic tapes. It is expected that the demand for iron oxide in magnetic tape manufacturing will continue since it is closely associated with the high-technology electronics industry.

Iron by-products such as ferric chloride and ferrous sulphate heptahydrate ($FeSO_4$-$7H_2O$) are widely used in water and sewage treatment plant processes. $FeSO_4$-$7H_2O$ can also be utilized as an additive in sludge fixation. Demand for these applications is likely to grow in the future.

3.2.2 Major Waste Streams Reported During the Survey

Steel plants surveyed in this study included both integrated works and facilities which were merely finishing works. The wastes reported included a wide variety of solids, liquids and sludges and representations of the types of wastes described in the previous section.

Major solid wastes reported include: slag, rubble and dust from the blast furnaces and steelmaking, mill scales, roll grindings, coke breeze, ammonia still lime sludge and foundry sand.

Liquid wastes reported in the survey include: coke plant discharges, blast furnace washwater, spent alkaline cleaning solutions, spent H_2SO_4 pickle liquors, rolling oils and miscellaneous oily effluents.

Ion exchange regenerant, heavy wire galvanizing spent flux, lime slurry, dictomaceous earth contaminated with oil and iron solids, various tank cleanout residues and miscellaneous sludges containing heavy metals were sludge wastes reported.

3.2.3 Approaches to Waste Reduction in Ontario and Current Waste Disposal Practices

Although the Ontario steelmaking industry generates large amounts of diverse liquid and solid wastes, a substantial fraction of the wastes are recovered and reused internally, and some is sold to outside customers. Many of the reuse/recycle and disposal/treatment practices described in the above sections have also been adopted by steel companies in Ontario. The technical barriers described limit extensive reuse/recycle of such wastes as blast furnace and steelmaking dusts, oily sludges and scales.

Internal recycle of wastes is well established in the steel industry. It is a common practice to recycle a large fraction of the dusts from the blast and steel furnaces, steelmaking slag as well as scales from continuous casting and hot rolling to the blast furnace through sintering or pelletizing. These practices have also been adopted by the Ontario steel industry. For example more than 50 percent of mill scale generated is recycled. Metal scraps are fed to the blast furnace.

Regeneration of spent hydrochloric acid pickle liquor is common practice in the steel industry. Stelco, for example, has been successfully regenerating spent hydrochloric acid using roasting and acid reabsorption since 1965(39). The regenerated acid is returned to the pickling lines and the iron by-product obtained (i.e. iron oxide) constitutes a marketable commodity for use as raw material in the ferrite industry. Some waste pickling liquor is used as a treatment chemical at sewage treatment plants.

In the early 1970's Dofasco changed from sulphuric acid pickling to hydrochloric acid pickling, selecting the Keramchemie/Lurgi fluidized bed reactor system(17). Reasons prompting the change included:

- better surface quality and superior finish attainable with hydrochloric acid;
- faster pickling;
- compared to sulphuric acid waste disposal, HCl regeneration was more attractive.

Due to the escalating price of oil, waste oils have become a valuable item and companies endeavour to utilize waste oils as much as possible. Skimming and chemical treatment are the most widely employed methods for oil recovery from aqueous effluents. Recovered oil is used for fuel; spreading waste oil on coal piles and internal roads for dust suppression is also a common practice. Some waste oils and oily wastewaters generated by Ontario steel plants are taken by contract disposers and oil re-refiners.

Blast furnace slag, which is an excellent aggregate for road construction and a multitude of other applications (e.g. railroad ballast, aggregate in portland cement concrete construction, raw material in hydraulic cement, manufacture of concrete blocks), finds a ready market. National Slag in Hamilton, Ontario is the chief buyer of slag from Ontario steel companies(48).

Steelmaking slag has been successfully used in asphaltic concrete mixes in the Hamilton area since 1969 and there has been a rapid increase in steel slag asphaltic concrete production since its properties (i.e. high skid resistance) were realized(10). Approximately 75,000 tonnes of steel slag were marketed in Ontario for asphaltic concrete mixes in 1978. Furthermore, steel slag has also been found to be an excellent ingredient in hot mixes for winter road patching.

Other wastes, or by-products, indicated as being sold by steel companies included coke breeze, coke plant desulphurization plant solids, waste chrome liquor, lime dust recovered from baghouses, anhydrous ammonia and mill scales.

Lime is used in a number of applications. It is relatively inexpensive and lime dust continues to be in demand for uses in agriculture.

Wastes which are not reused/recycled internally or sold to outside customers are handled by a variety of methods, including:

- biological treatment
- physical/chemical treatment
- trucking by contract hauling to Ontario or U.S. waste disposal sites
- internal landfill
- stockpiling (i.e. storage or "dumping" on company property).

Municipal sewers also provide an outlet for industrial wastewaters. Discharge to municipal sewers with or without pretreatment is practiced at several facilities.

Biological treatment is the most widespread method for treating coke plant wastewaters. Dofasco was among the first North American companies to install an activated sludge system for such discharges(15). The company is also currently investigating the feasibility of using a novel fluidized bed biological process for treating coke plant effluents and for treating combined coke plant/blast furnace washwaters.

Physical/chemical treatment methods in use include alkaline breakpoint chlorination for blast furnace washwater blowdown at Stelco's Nanticoke works(40). Neutralization of acidic and alkaline streams(46) ammonia stripping from coke plant effluents and ion exchange for removing chromium from the tin plating line discharges are also examples of physical/chemical treatment techniques in use by the Ontario steel industry. Chromium removal permits demineralized water to be recycled to plating lines.

Wet air oxidation is being evaluated by one firm for the conversion of ammonium thiocyanate to ammonium sulphate. The process is also under study for the treatment of Stretford liquor.

One company reported using decanter tank tar sludge, mixed with light oil as a fuel.

Solidification has become a popular technique for treating liquids and sludges since it offers the waste generator a means of disposing of a waste which otherwise would be chemically or physically unsuitable for landfill. With these considerations in view, some Ontario steel manufacturers have adopted solidification for coping with some of their wastes. For example, Dofasco has used solidification for steelmaking sludge (i.e. sludge from wet scrubbers serving melt shops) mixed with blast furnace sludge and dustcatcher dry grit(12). The solidified product is not only suitable for deposition into a sanitary landfill but it also has possibilities as subgrade fill material in road construction. Another steel company is employing solidification for the disposal of spent acids mixed with various other wastes.

Wastes reported which are disposed of by internal landfilling include oily filter cake and sludges arising from wastewater treatment operations.

Stockpiling on company property of course requires the plant to have sufficient real estate. Solid wastes are generally stockpiled until they can be returned to the steelmaking process or sold. According to the steel companies contacted, chief wastes which are stockpiled include various solid residues from the blast furnace and steelmaking, decanter tar sludge, mill scales, and cold rolling grindings.

Steel companies also reported storing PCBs since there is no other alternative available at the present time for the management of PCBs.

Steel industry wastes have found a variety of other disposal outlets. For example, when several municipal disposal sites in the Hamilton area were closed, steel industry wastes from Dofasco were found suitable for daily and final cover at landfill sites(35). The use of steel industry wastes composed of 60% solidified oxygen steel making oxides; 15% excavation, dredging and refractory rubble; 15% slag fines; 7% foundry sand; and 3% miscellaneous wastes resulted in large savings for the Regional Municipality of Hamilton-Wentworth.

The steel companies also employ contract haulers to take wastes to approved disposal sites in Ontario (e.g. the facilities operated by Tricil in Sarnia) and to U.S. locations in the Niagara Falls region. Shipment of wastes to U.S. sites is necessitated by the lack of adequate facilities suitable for the reception of industrial wastes in Ontario. Wastes trucked by contract disposal firms include zinc ammonium chloride flux, sulphuric acid pickle liquor, ion exchange regenerant, alkaline cleaning solutions, foundry sand, trichloroethylene degreaser solution, oily sludges from tank cleanout and various heavy metal sludges.

Another possible outlet for wastes is through waste exchange. However, steel companies indicated that although they've listed with the Canadian Waste Exchange the response has been disappointing. The major Ontario steel companies have large marketing departments which are involved not only in the selling of the various end-products but are also active in securing customers for wastes and by-products.

3.2.4 Potential Roles for OWMC to Encourage Waste Reduction

The Ontario steel industry is dominated by a few large firms. These companies, like all other businesses wishing to remain viable in a competitive world, are constantly modernizing their facilities and making improvements to increase productivity. Flow of raw materials is carefully controlled to minimize operating costs. Furthermore, large steel producers have capable technical staff with numerous highly trained specialists involved solely in environmental affairs.

Therefore, these companies are keenly aware of the latest technical developments not only in the manufacture of steel but also in pollution control technology. Internal research and demonstration projects, many of which involve pollution abatement, constitute an integral part of the operation of these firms. Aggressive marketing departments ensure that much of the wastes and by-products are disposed of at a profit. The Ontario steel industry has done much to control the discharge of gaseous, liquid and solid wastes in order to comply with existing environmental regulations.

There is a free flow of information between virtually all steel companies. Practically all North American steel producers belong to the American Iron and Steel Institute. This institute has a large staff of specialists and readily provides able assistance to members in all aspects of steelmaking. The Institute also sponsors research programs and demonstration studies in a variety of areas, including pollution abatement.

Consequently, the steel companies see a limited role for the OWMC in becoming involved with pollution control and/or reuse/recycle technology in the industry. Providing analytical services at a reasonable cost and funding research studies and demonstration projects were some of the suggestions as possible roles for OWMC.

More specifically, OWMC financial assistance would be welcome in identifying reuse/recycle possibilities and/or improved treatment disposal methods for the following wastes:

- spent alkaline cleaning solutions
- chromium wastewaters
- spent sulfuric acid pickle liquor
- oily mill scales and sludges.

Research projects concerned with any aspects of sludge management (e.g. dewatering and disposal) as well as fundamental studies aimed at increasing the efficiency of the biological treatment of coke plant discharges were other areas where OWMC could play a role.

Some of the companies also indicated that OWMC should give a high priority to solving the PCBs disposal problem.

3.2.5 Trends in Waste Quality and Quantity

As in all industries, the amount and characteristics of the wastes generated by the iron and steel producers are influenced by a multitude of factors. Included among these are:

- raw materials used

- manufacturing technology employed

- production levels and production efficiency

- reuse/recycle practices and pollution control techniques implemented

- available markets for by-products and wastes
- prevailing environmental regulations.

The current economic conditions have been particularly severe on the iron and steel industry and consequently, production levels are substantially down. The financial reversal experienced by the iron and steel industry has had serious repercussions on available funds for research and development work and capital outlays.

Since waste generation is primarily a function of production, when general economic conditions improve and industries consuming the products of the steel industry recover, the amount of wastes and by-products should also increase.

The steel industry has done much to meet waste discharge requirements. However, should prevailing environmental regulations become stricter, more treatment residues in the form of dusts and sludges are likely to be generated.

Modernization of various manufacturing processes and improvements in production efficiency should lead to decreased waste volumes and the elimination of certain waste streams. Likewise, implementation of more reuse/recycle practices and expanded marketing of wastes and byproducts will reduce the amount of wastes and eliminate a number of waste streams.

However, as in all competitive businesses, economic considerations are the primary factors influencing decisions in the iron and steel industry. There is an incentive for reuse/recycle of wastes only if such practices are more economically attractive than treatment/disposal (in accordance with environmental regulations).

3.3 METAL CASTING AND FOUNDRIES

Foundries utilize large quantities of waste materials. Scrap iron and steel are a major source of raw materials for ferrous castings. Reclaimed copper, aluminum, lead, tin, zinc and other metals are also recycled in making castings.

A casting may be defined as a metal object which is obtained by directly pouring liquid metal into a mold or cavity and allowing it to solidify. Founding or casting is the manufacturing process for the production of castings and a foundry is an establishment where the manufacturing process is carried out.

The industry is basically divided between manufacturing foundries which produce great quantities of identical castings, and jobbing foundries, which produce smaller numbers of a wider selection of castings, often quite intricate. Commercial foundries market their own castings, while captive foundries create parts for a parent company's products; examples are the captive foundries of motor vehicle manufacturers and machine tool manufacturers.

Since castings may be made of a wide variety of materials, including various types of iron, steel, aluminum, copper, bronze and zinc, foundries may be classified as ferrous and non-ferrous, or more specifically as iron, steel and malleable, or brass and bronze or light metals (aluminum and magnesium) foundries.

The basic casting processes are(50):

- Sand castings which generally include all molding processes employing so-called granulated compact molds and requiring molds for individual castings; therefore, although the mold material is usually reused, the mold itself cannot be reused.

- Permanent mold castings which use metallic or other molds which can be reused.

- Die castings also involve metallic permanent molds or dies. However, they differ from other permanent mold castings in that metal is introduced into the mold under pressure.

- Both metallic (i.e., permanent) or aggregate (i.e., sand) molds may be employed for centrifugal castings based on centrifugal force distributing the metal in the mold.

Once solidified, the casting must be rid, through machining, grinding, hammering or other processes, of extra metal or pieces of mold which have adhered to it. Additional processing, (e.g. heat treatment), may take place before testing for quality and before customer specified surface finishes are applied.

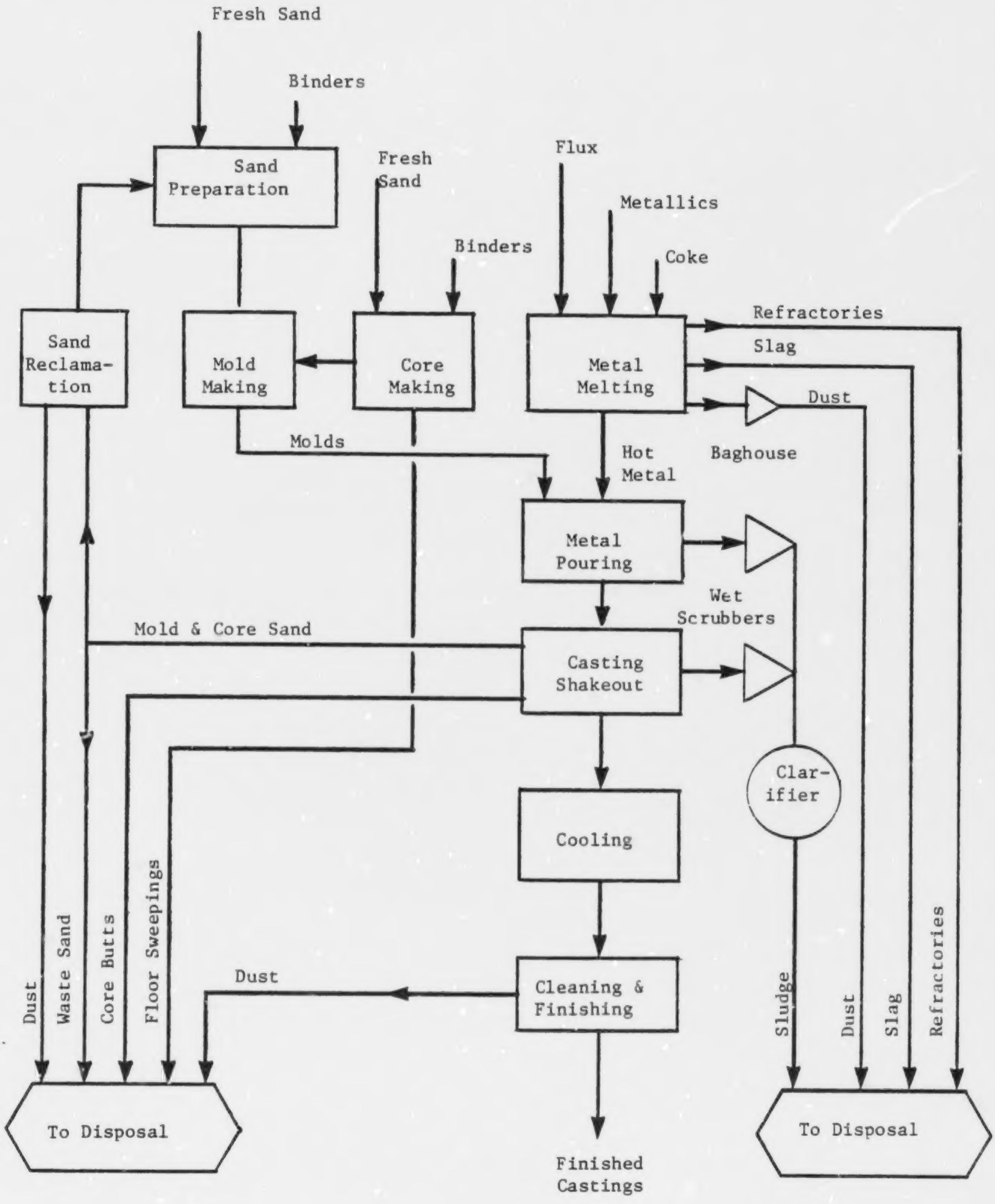
Since ferrous foundries (i.e., gray and ductile iron castings, malleable iron castings and steel castings) comprise the major segment of the foundry industry in Ontario, the ensuing discussion is confined largely to these foundry operations and is taken largely from Leonard et al(27).

3.3.1 Major Processes, Waste Streams and Reduction Techniques

(a) Process Outline

Foundry processing steps and major waste streams generated are depicted in Figure 3.2. Sand preparation, mold and core making, metal melting and pouring, casting shakeout, cleaning and finishing, comprise the main processing steps.

Because of its importance in foundries, much has been written about sand preparation(20, 21). Major constituents are clay bonded silica sand, organic additives, bentonite clay and water. In order to obtain certain properties, a small fraction of carbonaceous material (e.g., bituminous coal, fuel oil, or finely ground cellulosic material) may also be added to the sand. Molds are made by packing the molding sand around previously prepared patterns, yielding the desired shapes.


Fresh Sand
Binders
Sand Preparation
Fresh Sand
Flux
Metallics
Binders
Coke
Sand Reclamation
Mold Making
Core Making
Metal Melting
Refractories
Slag
Dust
Molds
Hot Metal
Baghouse
Metal Pouring
Wet Scrubbers
Mold & Core Sand
Casting Shakeout
Clarifier
Cooling
Floor Sweepings
Waste Sand
Core Butts
Dust
Dust
Cleaning & Finishing
Sludge
Dust
Slag
Refractories
To Disposal
To Disposal
Finished Castings

Source: Leonard et al., 1977

FIG 3.2 FOUNDRY OPERATIONS.

If the castings have hollows or recesses, cores are required to complete the mold. Since the cores must be removed after the castings have solidified, core sands require special properties to facilitate their removal. These properties are obtained by employing special binders. Most commonly used binders for this purpose are:

- Combinations of vegetable, fish and petroleum oils.
- Phenol formaldehyde resins.
- Sodium silicate.
- Phenolic isocyanate.
- Alkyd isocyanate.
- Mixtures of urea and furfural alcohols.

Numerous companies manufacture and/or sell such binders, and one of the leading suppliers is the Ashland Chemical Co. Comprehensive descriptions of the properties, applications, etc. of these binders may be obtained from technical brochures prepared by the manufacturers/distributors and from articles appearing in such publications as Foundry M & T and Modern Casting.

Besides special binders, a variety of other materials (i.e., iron oxide, ground corn flour, coke pitch) are often incorporated into core sands. These enhance the removal of the cores.

When the cores have been formed and cured, they are combined with the final molds and the product is transferred to the metal pouring site. Molten metal of the desired composition is prepared in one of several different types of commonly employed furnaces; cupola furnace, electric arc furnace or induction furnace. Flux material (i.e., limestone, fluorspar and soda ash), coke and metallics constitute the charge materials for the cupola furnace. Electric arc or induction furnaces do not require coke. Purchased scrap along with some which is internally generated make up most of the metallic charge. Most of the gray and ductile iron castings in North America are produced in cupolas and electric induction furnaces. On the other hand, virtually all the steel castings are produced in electric arc furnaces.

After tapping the molten metal from the furnaces into ladles, it is poured into the molds. Following solidification of the castings, they are separated from the molds and are cooled. Cleaning and finishing, (i.e. shot blasting, chipping and grinding), comprise the final processing steps.

After casting shakeout, the mold and core sand are screened and the bulk of the molding sand, along with the degraded core sand, is returned to molding sand preparation (i.e., it is recycled). However, large remnants of undisintegrated cores (called core butts) which have retained most of the binders are discharged to the disposal area where they are collected along with other solid wastes. In some foundries a portion of the sand is passed through a reclamation system and then returned to either the core or molding sand mixing operation.

Consequently, only a proportion of the sand used in the process is wasted. This sand is bled off the circulating system and is replenished with fresh sand to balance the system. (Figure 1.2.) Since core sands have more stringent specifications, new sand is used mainly for cores.

(b) Quantity and Quality of the Wastes Generated

Although the general types of wastes produced are basically independent of the metal being cast and the type of furnace employed, the quantity of wastes are affected by the type of metal cast and furnace used.

Because foundries generate significant amounts of solid wastes, some of which may be hazardous, much work has been done in the past decade to accurately quantify and characterize the wastes generated from foundries. Until environmental regulatory agencies began to take a closer look at foundries, accurate information on the quantity and quality of foundry wastes was not available.

Over 75% of the wastes generated by sand foundries originate from coremaking and molding. The remainder comes from melting operations with small contributions from cleaning and heating processes and air pollution control devices. Aside from the cast product, the only solid materials leaving a ferrous foundry are landfillable wastes. Nonferrous foundries, however, generate additional metallic wastes in the form of dross and grinding residues; these are returned to smelters for metal reclamation and the refined material is returned to the foundry as ingot.

According to the American Foundrymen's Society's Solid Waste Disposal Manual, an average of 0.30 tonnes of solid waste are produced per tonne of ferrous casting and 0.5 tons of solid waste per ton of non-ferrous metal cast(23).

An estimate of waste requiring landfill disposal from three greensand molding foundries is shown in Table 3-8.

Types and quantities of waste generated by ferrous foundries estimated in a comprehensive U.S. study are summarized in Table 3-9. Discarded sand comprises the bulk of the wastes.

There is some conflicting opinion in published material concerning the characteristics, and thus hazard potential of various foundry wastes. In the United States, foundry waste sand is not specifically listed as a hazardous waste in EPA regulations. Generators, however, are required to determine if the solid waste is hazardous by testing for corrosivity, reactivity, ignitibility or EP toxicity(24).

TABLE 3-8

ESTIMATED KILOGRAMS OF MATERIAL TO LANDFILL PER TONNE OF METAL SHIPPED FOR THREE GREENSAND FOUNDRIES

Type of Waste	Malleable Iron Foundries	Ductile Iron Foundries	Gray and Ductile Iron Foundries
Refractories	20 (2%)	27 (2%)	9 (1%)
Sand	785 (88%)	1,148 (79%)	542 (66%)
Slag	49 (5%)	198 (14%)	135 (16%)
Other	41 (5%)	76 (5%)	140 (17%)
Total	895	1,449	826

Source: Boyle and Ham, 1979(5).

TABLE 3-9

IRON AND STEEL FOUNDRIES - WASTE GENERATION FACTORS

Type of Waste	Generation Factor (kg/tonne of finished casting)	
Gray and ductile iron foundries		
Slag	62.9	(8%)
Sludge	32.8	4%
Dust	65.6	(8.5%)
Sand	600	(77.5%)
Refractories	13.8	(2%)
Total	775.1	(100%)
Malleable iron foundries		
Slag	55.5	(7%)
Sludge	31.9	(4%)
Dust	64.7	(8.5%)
Sand	600	(78.5%)
Refractories	13.2	(2%)
Total	765.2	(100%)
Steel Foundries		
Slag	122	(10%)
Sludge	36.4	(3%)
Dust	186	(16%)
Sand	780	(66.5%)
Refractories	53	(4.5%)
Total	1,177.4	(100%)

Source: Leonard et al., 1977(27)

Areas in the foundry which deserve closer scrutiny in order to determine whether or not the wastes generated are hazardous include(24).

- Machining, plating and painting operations.

- Inadvertent mixing of hazardous wastes with other foundry process solid wastes.

- Use of melt materials containing significant amounts of lead, Cadmium and Chromium.

- Certain coremaking processes which may generate corrosive wastes.

- Use of calcium carbide desulphurization in the production of ductile iron which may generate ignitable and reactive slag.

- Non-ferrous alloy casting which contains lead.

Phenols and heavy metals are pollutants of concern most likely to be present in foundry wastes. Essentially any waste sand from a foundry core or mold process which uses organic binders may contain phenols(23). Leachable phenols from waste sand depend on a number of factors, including:(23)

- Sand-to-metal ratio
- Binder type
- Binder level
- Degree of cure
- Phenol content of the binder
- Extent of binder thermal decomposition and rearrangement
- Metal pouring temperature
- Reclaim sand loss on ignition
- Cooling time between pouring and shakeout.

To determine accurately the levels of phenols in any given foundry sand sample, leaching tests must be employed.

Leachable phenols are not considered a pressing problem because phenols are amenable to biodegradation under both aerobic and anaerobic conditions and because both the concentrations and the total amount of phenols present in the sands tend to be low(23).

According to a publication by Leonard et al(27) solubility tests on waste sand from ferrous foundries did not show significant leaching of phenols or heavy metals. Likewise, no heavy metals were detected in significant concentration when dust, sludges, slag, refractories or floor sweepings of such foundries were tested in a similar manner. Consequently, all wastes were classified as non-hazardous.

In a study conducted by Boyle et al.(6) which was aimed at determining the concentrations of cadmium, chromium and lead from samples of cupola dusts or sludges collected from various gray iron foundries, cupola dusts or sludges from several of the foundries were found to be EP toxic. Cupola dusts or sludges containing particles visually classified as very fine were more likely to be EP toxic than coarse wastes. The foundry process most likely to generate EP toxic dusts or sludges is the electric arc furnace.

In evaluating leaching potential of foundry sands it is necessary to determine:

- total quality of waste generated
- types and amounts of resins used
- type of foundry process
- process temperatures.

The characteristics of foundry wastes can be quite variable and further study is required to assess the leachability and hazardous nature of waste foundry sand. Descriptions of leachate testing procedures may be found in the publications by Boyle and Ham(5) Boyle et al.(6); and the American Foundrymen's Society(2).

(c) Treatment and Disposal Technology

Open dumping and landfilling are the main methods currently in use for the disposal of sand and other solid foundry wastes(24, 27). Some foundries dispose of waste on their own property while others rely on municipal or private disposal sites. According to extensive studies conducted in the U.S., England, Sweden and West Germany, disposal of phenol-containing sand in landfills seldom results in phenol-related environmental problems(23). However, certain cupola dusts have been identified as EP toxic and therefore, mixing sand with other wastes prior to disposal, as is commonly done is a practice that requires reassessment.

(d) Reuse/Recycle Practices

Scrap is one of the raw materials used in foundries and thus any internally generated metallic scraps, turnings, shavings and the like are recycled. Recovered metals and alloys not recycled within the foundry can be sold to scrap dealers. Sand recycling which has already been described is a common practice. Sand reclamation may be accomplished through the use of vibratory or rotary attrition units(47, 43, 51). Reclamation is not equivalent to regeneration or restoration since it is not possible to regenerate the sand to the quality of new sand. Thermal reclamation processes, already widely used in Japan and Europe, are gaining acceptance in North America according to foundry experts due to rising operating costs, shortage of suitable disposal sites and high costs associated with waste disposal(8, 20, 21, 45). With such reclamation systems, more sand can be returned to the molding and core making operations, thus further reducing the amount bled as waste from the recirculating system.

Waste foundry sand has found a variety of useful applications. For example, it can be used as a kiln feed in portland cement manufacture(16). In many locations it is utilized in road construction. Experience at a number of foundries has also demonstrated that waste sand is an excellent cover material in foundry waste landfills or for co-disposal in municipal landfills(2, 24, 44).

3.3.2 Major Waste Streams Reported During the Survey

As mentioned in the above section, discarded sand constitutes the largest single source of waste in most foundries, and Ontario foundries did not differ in this respect. When most companies reported waste sand, it was actually sand mixed with other solid residues (i.e. slag, refractories, dust and sludges). The firms tended to give a single figure since it is common practice to mix all solid wastes prior to disposal.

Other types of wastes mentioned included metal drosses and various metal residues (e.g., grindings) which are largely recycled or sold to scrap dealers.

3.3.3 Approaches to Waste Reduction in Ontario and Current Waste Disposal Practices

As outlined under "Process Description" following casting shakeout, the bulk of the mold and core sand is recycled to molding sand preparation with only a fraction of the sand being bled from the process as waste. Most Ontario foundries contacted also operate in this manner. Scraps, drosses and the like waste are either returned to the process or are sold to scrap dealers. One firm indicated that it is selling iron shot blast residues to a contractor who takes this waste for its value as an ingredient in high strength concrete.

Several companies mentioned that although the slag could be utilized as an aggregate in road construction, the relatively small quantities generated at individual foundries make it economically unattractive for slag processors and other potential customers to collect it.

Although several foundries indicated that they are aware of reclamation systems which would decrease the amount of sand wastes, they also stated that installing such systems would involve substantial capital outlays which could not be justified given their current level of operation and the poor economic conditions prevailing.

Disposal of solid foundry wastes (i.e., sand, slag, refractories, dusts, sludges, etc.) is accomplished by landfilling on company property or by contract haulers who truck the wastes to approved disposal sites such as old quarries. Waste foundry sand taken by contractors is also used to a certain extent in road construction in southern Ontario.

Effluent from wet air pollution control devices is usually discharged into municipal sewers following removal of coarse solids in the form of sludge. One company indicated that scrubber sludges are dumped on company property. After evaporation, the amount of solid residues left on the ground is minimal, and no problems have been encountered with this disposal approach.

Some metal casters operating plating lines have adopted a variety of methods to cope with the liquid effluent. One company reported using sodium hypochlorite to destroy cyanide from the copper plating tanks, sodium metabisulphite to reduce hexavalent chromium to the trivalent form, and neutralization to precipitate out heavy metals(30). Metal-laden sludges generated are landfilled. The firm also operates a Corning evaporator to concentrate chrome solutions and the recovered chrome is recycled to the plating process.

Virtually all companies interviewed stated that as far as they are concerned, all environmental matters are well under control, and moreover they are closely co-operating with all the pertinent regulatory agencies (i.e. Ontario Ministry of the Environment and municipal authorities) in the disposal of their wastes and constantly making improvements to their processes in order to increase productivity and minimize waste generation.

Only a few of the foundries were familiar with the Canadian Waste Materials Exchange and none have wastes listed. Some firms indicated that perhaps in the future they'll try to utilize it for the disposal of some of their wastes, particularly slags.

3.3.4 Potential Roles for OWMC to Encourage Waste Reduction

When asked what role OWMC could play in their environmental management program, most foundries replied that they would like to see OWMC ensure that readily available, inexpensive landfill sites remain available for the disposal of solid wastes. Several mentioned that they would welcome any assistance in finding markets for slag.

However, from the discussions held with foundries, waste disposers, environmental regulatory agencies, suppliers of foundry sand binders and sand reclamation systems, and from reviewing the latest articles on environmental management in such trade publications as Foundry M & T and Modern Casting, a number of other possible roles for OWMC became evident to those stated explicitly by the foundries interviewed.

Unlike the iron and steel companies, most Ontario foundries are small firms with small staff. Moreover, such associations as the Canadian Copper and Brass Development Association and the Ontario Chapter of the American Foundrymen's Society are only marginally involved in environmental affairs. Consequently, foundries tend to be unaware of the latest developments in pollution control technology and do not have the personnel to carry out studies, which require environmental expertise.

Thus, OWMC could play a vital role by acting as an information clearinghouse, providing advice on applicable pollution control methods, analytical determinations and environmental regulations affecting foundries. Such information could be channelled to the foundries through the existing trade/technical associations or by direct contact with the firms.

Although a considerable body of data has been generated on the characteristics of foundry wastes, much work remains to be done since there are substantial discrepancies among past studies. Accurate characterization of the wastes is essential to determine what fraction of the wastes are hazardous and require the services of an OWMC waste disposal facility. The amount of foundry wastes destined for an OWMC facility could exert a major impact on the size of the facility since foundry wastes comprise a large fraction of industrial solid wastes generated in Ontario.

Therefore, OWMC could consider a comprehensive program to ascertain the amount of solid wastes produced by various foundries (i.e. captive and job; ferrous and non-ferrous), their chemical characteristics and leachate potential, particularly with regards to phenols and heavy metals. Assessing the leaching potential of various foundry wastes would necessitate the development of a standardized, realistic extraction procedure.

Since the main drawback to marketing foundry slags appears to be the small quantities generated at individual plants, OWMC could investigate the practicality of establishing centralized collection stations which would receive slags from foundries and in turn would market the slags in large bulk to interested customers. Purchasers would only be interested in such slags if they met certain physical and chemical criteria; therefore, a market study identifying potential customers and their requirements would have to be conducted first.

OWMC could also consider sponsoring studies to stimulate the more extensive utilization of waste foundry sand in such established applications as road construction, cement manufacturing and as cover material in municipal landfills. Such studies are needed since regulatory agencies generally evaluate the use of sands and slag in off-site construction and municipal landfills on a case-by-case basis, requiring the generators to demonstrate through physical and chemical testing that the waste is suitable for these applications.

OWMC could consider undertaking studies to evaluate the viability of various sand reclamation systems at Ontario foundries and also investigate the feasibility of establishing centralized reclamation facilities which in the opinion of certain foundry experts will be the trend in the future(21). Particular attention should be given to thermal units which are already widely employed in Europe(22). According to some recent publications, various mobile and package reclamation systems available on the market are particularly suited for small foundries because they can be rented or installed at reasonable prices(14).

3.3.5 Trends in Waste Quality and Quantity

Most all of the factors affecting the quality and quantity of the wastes from the iron and steel industry also apply to foundries. The leading factors peculiar to foundries which have a major impact on waste quantity and quality include:

- sand binder composition
- new molding techniques, e.g. vacuum molding
- more extensive utilization of sand reclamation systems
- re-classification of certain foundry wastes as hazardous from non-hazardous by environmental regulatory agencies.

New sand binder formulations are constantly introduced onto the market and serious consideration has been given to the elimination of phenolic binders. The binders used are one of the main variables affecting the quality of the leachate solution generated when waste sand samples are subjected to an extraction test.

The vacuum molding technique which requires significantly less sand and thus generates less waste sand is a recent innovation but has yet to be implemented widely.

If more foundries install reclamation systems, the amount of sand wasted and requiring disposal will decrease. However, since such systems are rather costly, the purchase of sand reclamation units in the near future will be most likely confined to the larger foundries using expensive sands.

It is possible that as environmental regulations become tighter and foundry wastes become more closely scrutinized less wastes will be permitted for use in constructive applications (i.e. landfill cover, road construction etc.) and more foundry wastes will require disposal into designated waste disposal sites.

However, given current economic conditions, foundries are not likely to implement innovative technologies and therefore, the quantity and quality of foundry solid wastes generated in the near future are not expected to change significantly.

3.4 PRIMARY AND SECONDARY METAL SMELTING AND REFINING

The primary metal smelting and refining industries use ore concentrates or other natural resources as raw materials. In Ontario as well as throughout North America the larger primary nonferrous smelting and refining industries are characterized by a relatively small number of plants with large production capacities and are generally located in rural areas near mine-mill complexes.

The major raw materials for the secondary smelting and refining industries are scrap metal or some other type of waste. These industries are usually located in urban centres where scrap material is available.

Pollution from secondary lead smelters has been a major environmental issue in several Canadian cities, particularly Toronto, during the past few years.

Primary and secondary smelting and refining industries are complex and highly diversified and thus it is not practical to give a thorough description of the processing steps employed for the production of various metals. However, there are several excellent sources which readily provide such information, particularly the text authored by Leonard et al.(26, 27).

The following discussion focuses on the primary copper smelting and refining industry which is a major industry in Ontario. Most of the other primary metal smelting and refining operations of interest in Ontario employ roughly similar processing steps and generate similar types of wastes. Also described below are the steps involved and the wastes generated by the secondary smelting and refining of copper.

3.4.1 Major Processes, Waste Streams and Reduction Techniques

Process Description

The three major operations in producing copper metal are roasting, smelting and refining. The chief process steps involved in the smelting and fire refining of copper consist of(26) roasting to reduce the sulphur content; reverberatory furnace smelting to form copper sulphide matte and a siliceous slag; oxidation of the molten sulphide matte to give molten "blister" copper and an iron silicate slag which is returned to the reverberatory; and furnace purification (i.e. fire-refining) of the molten copper so that anodes suitable for electrolytic refining can be cast (or a copper product can be marketed directly).

Since roaster gases contain high levels of sulphur dioxide, sulphuric acid can be produced in large quantities. Some of this acid is used in the electrolytic refinery. Acid plant blowdown slurry effluent generates a sludge.

Electrolytic refinery feed material consists solely of cast copper anodes with a purity of approximately 99.0 to 99.7% copper while the cathode copper product arising from electrolysis contains approximately 99.997 copper.

The main processing steps in electrolytic refining include: electrolysis in cells; melting and refining; and casting into various shapes. Recovery of slimes (rich in Selenium, Tellurium, Silver, Gold and Platinum) from the cell bottoms, and electrolyte purification permitting electrolyte reuse and the recovery of valuable materials are important auxiliary operations.

The major wastes generated from primary copper smelting and refining are shown in Table 3-10 along with the types and quantities of the predominant wastes of concern from various other primary metal smelting and refining operations. Dusts collected from roasters, reverberatory furnaces and converters are generally recycled.

TABLE 3-10

RESIDUAL GENERATION FACTORS FOR METAL SMELTING AND REFINING[1]

Metal Category	Type of Residual	Residual Factor, kg/tonne of Product
Primary copper		
Smelting and fire refining	Reverberatory slag	3,000
	Acid plant sludges	2.7
	Dusts	17
	Miscellaneous slurries	17
Electrolytic refining	Miscellaneous slurries	2.4
Primary lead	Blast furnace slag	410
	Slag fines	30
	Acid plant sludge	40
	Sinter scrubber sludge[2]	19
Primary Zinc	Acid plant sludge[2]	17
Electrolytic	Miscellaneous sludges[2]	9.1
Pyrometallurgical	Retort residue	1,050
	Acid plant sludge[2]	122
	Retort residue ("blue powder")[2]	10
	Cadmium plant residue	1.8
Primary aluminum	Shot blast dust	5
	Pot line scrubber, sludge[2]	29.3
	Pot line skimmings[2]	5.5
	Spent potliners[2]	53
	Cast house dust	2.5
Primary antimony		
Pyrometallurgical	Blast furnace slag	2,800
Electrolytic	Anolyte sludge	210
Primary mercury	Kiln or retort residue	207,000
Primary titanium	Chlorination sludge	330
Primary tungsten	Digestion residue	50
Primary tin	Smelting slag	915

[1] Residuals immediately recycled to process (e.g., dusts) are not included.

[2] May be recycled after storage periods of months to years.

Source: Leonard, et al., 1977(27).

Industries employing pyrometallurgical processes (e.g. reverberatory furnaces) generate huge quantities of slag. Over 95% of land disposed residues from primary copper smelting and fire refining, primary lead smelting, secondary lead smelting and secondary copper smelting are slags or retort residues(27). About 70 to 85% of the total residues from primary pyrometallurgical zinc smelting and refining, and secondary aluminum smelting and refining are slags.

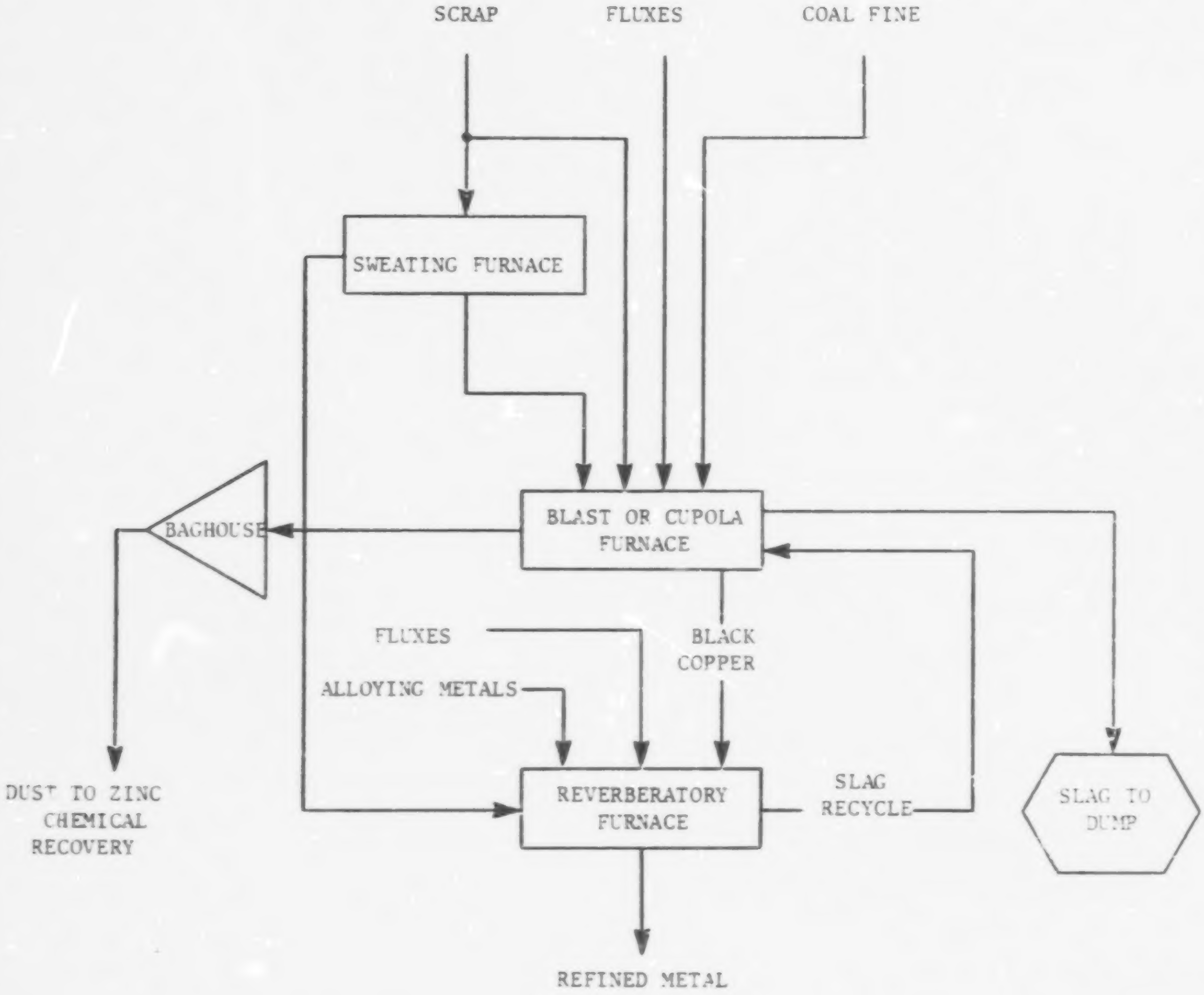
Processes using electrowinning of metals (e.g. copper and zinc) generate sludge residues as a result of treating spent electrolyte solutions.

In addition to secondary copper smelters, recovery of copper from scrap is conducted by primary copper producers, brass mills, foundries, chemical plants and sundry manufacturers. Copper-base alloys in the form of brass and bronze ingots are the main products of secondary copper smelters.

While the typical secondary copper producer is engaged in the production of copper and brass and bronze alloys by pyrometallurgical processes, electrolytically refined copper is more likely to be produced at primary copper refineries.

The basic processing steps and waste flows in a generalized secondary copper and brass smelting operation are depicted in Fig. 3.3.

Low grade scrap mixtures are melted with suitable fluxes (i.e. limestone, borax and waste glass) during cupola and blast furnace processing. A basic difference between cupolas and blast furnaces is that the former are not designed for the reduction of copper compounds, and require less fuel and use lower blast temperatures. Molten metal and slag are tapped periodically. Black copper from the blast furnaces or cupolas is further refined by converting metal contaminants to oxides and removing them with the slag. This slag is returned to the blast furnace for additional copper recovery. When high grade scrap is smelted, the melted scrap is fed directly to the reverberatory furnace rather than the blast furnaces and as shown in Fig. 3.3 the slag is recycled to the blast furnace.


SCRAP
FLUXES
COAL FINE
SWEATING FURNACE
BAGHOUSE
BLAST OR CUPOLA FURNACE
FLUXES
ALLOYING METALS
BLACK COPPER
DUST TO ZINC CHEMICAL RECOVERY
REVERBERATORY FURNACE
SLAG RECYCLE
SLAG TO DUMP
REFINED METAL

Source: Leonard et al., 1977

FIG.3.3 SECONDARY COPPER SMELTING AND PYROMETALLURGICAL REFINING.

In plants employing electrolytic refining, copper obtained from the reverberatory furnace is further refined. This process is carried out by dissolving the copper in sulphuric acid then electrolytically redepositing the pure copper on the cathodes of electrolytic cells.

The main wastes generated from secondary copper smelting are blast furnace dust, blast furnace slag and sludge from the treatment of spent electrolyte. Because of its high zinc content, the dust is a marketable commodity and is usually sold to chemical firms and paint manufacturers.

The principal hazardous constituents found in primary and secondary smelting residues (i.e. slags and sludges) are such heavy metals such as Zinc, Copper, Chromium, Nickel, Cadmium and Lead.

Lagooning and open dumping are the main practices used in primary and secondary nonferrous smelting and refining industries to dispose residues(27). Slags and other solid wastes are generally open dumped on site. Effluent from wet air pollution control devices and process wastewater are generally routed to settling pits or lagoons with or without chemical treatment. Settled sludge is often dredged from pits or lagoons and stored or disposed of on land. However, facilities which generate small quantities of sludge will often leave sludges permanently in lagoons.

Metal recovery from sludges and various other solid discards is possible; however, often these residues are stored for extended periods before being processed for additional metal recovery.

Certain residues generated by metal smelting and refining industries also find usage in a number of applications. For example, in Ontario nickel and copper slags are often utilized as road base material and rail ballast(10). Slags from copper smelters have also been reprocessed into building materials by blowing air and carbon dioxide through the slag in the electrolytic furnace and feeding lime and solid reducing agents onto the surface of the slag(11).

Using slags for mine backfilling and as an ingredient in portland cement manufacture are some of the current research activities in progress in Canada for the more extensive utilization of non-ferrous slags.

3.4.2 Major Waste Streams Reported During the Survey

Chief wastes reported by the primary smelters were slags, iron oxides, scrap metal and used oils. The companies also indicated that they are accumulating large quantities of PCB wastes.

The only wastes reported by the secondary metal smelters contacted were sludges containing heavy metals (e.g. copper) and various brass and bronze scraps.

3.4.3 Approaches to Waste Reduction in Ontario and Current Waste Disposal Practices

Slags generated by primary smelters are largely stockpiled, and some are used locally or sold as road bedding and rail ballast. Iron oxide wastes are stockpiled and there is only a market for it when the iron ore production industry is experiencing a strike. A small quantity of the iron ore is sold to paint and pigment manufacturers and there is some developmental work in progress to find other possible outlets for it. One firm indicated that it sells its metal scraps to a metal dealer while another firm stated that waste oil is used for road oiling. Studies have been initiated to utilize waste oil as fuel in boilers.

According to the primary smelters interviewed, one of the main reasons that limit the more widespread marketing and utilization of slags and iron ore wastes is the remoteness of the smelters from potential markets in southern Ontario which make transportation costs prohibitively expensive.

According to the secondary smelters interviewed, any metal scraps generated are recycled while the metal-contaminated sludges are taken by contract haulers for disposal. The small volumes of sludges generated make it uneconomical to reclaim the metals.

Although the primary smelters have listed wastes with the Canadian Waste Materials Exchange, to date, no exchanges have been made.

One secondary metal smelter mentioned that he has used the Canadian Waste Materials Exchange in the past but without any positive results while the others, although aware of its existence, have never listed.

3.3.4 Potential Roles for OWMC to Encourage Waste Reduction

The primary smelters perceived a limited role for OWMC in the disposal of their wastes; one firm indicated that OWMC could perhaps help by identifying new outlets for the slag or lobby for subsidized transportation, thereby enabling this waste to reach potential markets at a reasonable price. The companies also indicated that OWMC should give a high priority in finding a solution for the disposal of PCBs.

The secondary metal smelters contacted also saw very little role for OWMC, stating that their waste volumes are small and that they are already in the waste reuse/recycle business. However, one firm suggested that financial assistance to carry out some research projects in the future would be one appropriate area of involvement for OWMC.

3.4.5 Trends in Waste Quality and Quantity

Most of the factors influencing waste quantity and quality cited in the previous sections are also applicable to this industrial sector. Moreover, the current recession has been particularly severe on the primary metal smelters and refiners in Ontario. Prolonged plant shutdowns have been the rule rather than the exception during the past year.

According to an authoritative US publication, the relative proportions of generated sludges, slags and other residuals is expected to remain steady in the near future(27). Because technologies employed at Canadian plants are very similar to those in the US and given the close economic ties between the two countries, the same prediction would most likely hold for Canadian facilities.

3.5 OTHER PRIMARY METALS INDUSTRIES

In addition to the industries described in the above sections, SIC 33 includes plants engaged in heat treating and wire drawing and in the production of various tubes, sheets, bars and strips.

3.5.1 Major Processes, Waste Streams and Reduction Techniques

Process Descriptions

Such items as bars, rods, tubes and wires are produced by drawing, a cold working operation. For example, in wire drawing, a circular rod is reduced to wire by pulling it through hardened steel dies of successively smaller diameters. Tube drawing differs from wire drawing in that the inside diameter of the tube must be supported while it is passing through the die. Friction created during the processing is reduced by the application of lubricants.

Other processing activities usually associated with wire and rod production include cleaning and coating operations. These are identical to many of the processes already described under Cold Finishing in the Iron and Steel Works section. For example, cleaning of the wires and rods prior to certain coating operations is carried out with sulphuric acid or hydrochloric acid. "Acid flux", i.e. zinc ammonium chloride is employed on galvanizing lines for cleaning prior to coating.

Typical wastes arising from such cleaning operations are characterized by high acidity, and the presence of objectionable levels of various heavy metals. Neutralization followed by discharge of treated effluent into municipal sewers and disposal of sludge into approved landfills is the most common waste management practice.

Heat treatment is a technique whereby a solid metal or alloy is subjected to heating and cooling processes in such a manner as to impart a variety of desired properties to the metal. Heat treating processes include annealing and normalizing, used to control hardness in hot or cold worked metals; hardening by heating and quenching of certain metals, principally steels; carburizing, in which carbon is introduced into the surface of low carbon steels by heating them in a carbon-rich media followed by quenching, tempering or drawing in which metals are heated at low temperatures for stress relieving or to modify the hardness of the quenched steels.(28, 32, 38, 9)

Heat treatment operations are carried out in batch or continuous furnaces in which reducing or oxidizing atmospheres may be present or they may be conducted in liquid heating media such as molten salts or lead. Water, brine, oil, molten salt and molten lead are among the quenching media used. Metal to be heat treated is often washed in alkaline solutions before heating and is usually cleaned following the treatment by washing, shot blasting, or pickling in acids.

Molten salt containing cyanide is widely used for heating and surface hardening of steels. Cyanide baths are generally used when direct heating methods will not impart the required surface characteristics(28). To some in the industry, cyanide-free or "neutral salts" are often satisfactory substitutes.

Wastes of primary concern from heat treating consist mainly of sodium and potassium cyanide salts. These wastes are generated from drag out; i.e. the salt is carried from the bath by the metal piece undergoing treatment. Salt baths themselves are discarded about once a year. The quenching medium contains residues of the bath salts and perhaps some solvent from the pre-treatment operations. Used solvents and alkaline cleaners are other wastes generated by heat treaters.

Chemical destruction is one of the most widely used methods for coping with the cyanide wastes. Electrolytic oxidation is an efficient and cost-effective alternative treatment technique(13). Disposal through contract hauling is also a common practice. Landfill is used for some untreated cyanides in liquid form, while cyanides in solid or semi-solid residue can be destroyed by incineration(28).

3.5.2 Major Waste Streams Reported During the Survey

Although a wide variety of wastes were reported by the firms interviewed from this group, waste quantities in general were small. Major waste streams cited included scrap metal, metallic residues (i.e. grindings, shreddings and shavings), waste oils, oily effluents and spent pickle liquor. Scrubber sludge, baghouse dust, miscellaneous metal-contaminated sludges, and various wastewaters containing dissolved organics, fluorides and nitrates were some of the other wastes mentioned.

3.5.3 Approaches to Waste Reduction in Ontario and Current Waste Disposal Practices

Scrap metals and metallic discards (i.e. shavings, grindings, shreddings) are sold largely to scrap dealers.

Waste oils are taken mainly by contract disposers with the generators often receiving some credit. In a few cases, waste oil is re-refined for its original usage and returned by the contractors for a fee. One company reported that expensive rolling oils are recovered internally while another firm stated that in the past, oil recycling was performed internally, but because the operations involved were too troublesome, too expensive and took up too much space, the company found it more convenient to ship it out to an oil re-refiner. Oils which are heavily contaminated and thus are unsuitable for reuse/recycle, are trucked to approved disposal sites.

Two firms mentioned that oil-coated metal particles are taken by contract disposers for copper recovery.

Scrubber sludge, containing high levels of heavy metals, is shipped from one firm to Great Britain for zinc and copper recovery. The same firm also mentioned that its baghouse dust and furnace residues are taken to a metal smelter for copper recovery.

Neutralization is employed at several plants to treat various wastewaters (e.g., spent pickle liquor). The resultant sludges are trucked to landfills while the treated effluent is discharged into the sewers. One company is currently evaluating solidification for the sludge arising from neutralization.

One firm reported that its zirconium metal grindings are currently disposed of by on-site incineration but this practice may cease in the near future since a potential buyer has been found for the metal which is a valuable commodity.

Only a few of the companies have listed with the Canadian Waste Materials Exchange and none received any positive results. However, a number of other firms mentioned that perhaps they'll utilize this waste exchange service for the disposal of some of their wastes in the future.

3.5.4 Potential Roles for OWMC to Encourage Waste Reduction

Few of the companies contacted saw any specific roles for OWMC. Several reasons were cited for this reply, including:

- Waste quantities generated are small and therefore do not pose any problems.

- Waste management practices (i.e. reuse/recycle and treatment/disposal) are already carried out in the most technically and economically advantageous manner.

- Companies are co-operating closely with pertinent environmental regulatory officials.

However, one company indicated that perhaps OWMC could help it in developing a method for utilizing its nutrient-rich wastewaters for agricultural applications or in devising practical methods for recovering fluorides from the effluent stream, given the fact that currently there is a fluoride shortage in Ontario. Another firm mentioned that it would welcome assistance in identifying viable methods for recovering copper from its scrap since the scrap dealer taking this material pays for it as if it were all iron while actually a substantial fraction is copper, and copper commands a higher price than iron.

Aiding heat treaters employing cyanide baths to cope with their wastes and encouraging these firms to change to non-cyanide systems would be perhaps the most valuable role for OWMC in this industrial segment. Heat treatment is a significant source of cyanide waste in Ontario and most of the province's heat treatment facilities are small operations with limited technical expertise. Thus, by providing information and/or technical expertise on the most appropriate treatment/disposal methods available, OWMC could ensure that heat treaters would manage their wastes in the most environmentally sound manner and at the same time, minimize the quantities requiring disposal at the proposed OWMC facility.

There are several cyanide-free heat treatment systems on the market and their advantages have been demonstrated in a number of cases. For example, converting from a salt bath to the fluidized bed process enabled an Alberta heat treater not only to operate more cost efficiently but also to eliminate the environmental problems associated with cyanide systems(52). Current economic conditions and high interest rates have been cited as the chief reasons why many Ontario firms, although interested in new, cyanide-free systems, have not made the conversion(17). Therefore, some form of financial assistance might stimulate more companies to convert.

3.5.5 Trends in Waste Quality and Quantity

Because of the diversity of the industries grouped into this category, it is difficult to analyze trends in waste quality and quantity. Factors affecting waste generation for other industrial sectors already cited are also largely applicable.

However, from the interviews and discussions conducted, it is evident that if heat treaters convert from cyanide baths to cyanide-free systems, a significant source of waste cyanides could be eliminated. Given the current economic conditions, however, it is most unlikely that such changes will occur to any significant extent in the near future.

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4.0 CHEMICAL MANUFACTURING INDUSTRY (SIC 28)

4.1 OVERVIEW OF THE CHEMICAL MANUFACTURING INDUSTRY

The chemical industry is responsible for the production of many thousands of compounds which, in turn, are employed by other industries. Chemical industries may produce basic chemicals which undergo several transformations by other chemical industries before consumption, (e.g. dyes), or consumption on-site at an integrated chemical facility. Basic chemicals such as mineral acids, chlorine, polyolefins, and cyclic chemicals, are generally produced at high productivity in larger facilities(1). In Ontario, there are a few integrated heavy chemical industries which are the only one or two sources of several basic chemicals.

Table 4-1 contains a listing of the number of plants and total production employees for Ontario chemical industries according to their primary Standard Industrial Classification (SIC).(2)

Chemical manufacture can involve a single process step such as ink compounding, or a complex sequence of unit operations and chemical reactions, to produce materials which are separated from reactant impurities, intermediates and other products. Chemical reactions are conducted in either continuous or batch reactors, often in the presence of catalysts. Separation and refining processes include distillation, stripping, extraction, drying, adsorption, centrifugation, filtration, crystallation, sedimentation, etc.

Most of the wastes from chemical manufacture result from process streams. These include impurities in raw materials, discarded chemical intermediates, catalysts, unwanted by-products, and unrecovered product. Other wastes are generated from cleaning operations, air emission control including filtered dusts and scrubber wastewaters, wastewater treatment sludges and maintenance related wastes such as lubricating oils, and spilled material.

TABLE 4-1
ONTARIO CHEMICAL INDUSTRY BY SIC[2]

SIC		Number of Plants	Number of Employees
2812	Alkalies and Chlorine	5	1,252
2813	Industrial Gases	23	1,409
2816	Inorganic Pigments	7	136
2819	Industrial Inorganic Chemicals	37	4,278
2821	Plastics Synthetic Resins	36	3,212
2822	Synthetic Rubber	5	2,978
2823	Cellulosic Fibres	3	580
2824	Synthetic Fibres (Non Cellulosic)	8	3,372
2831	Biological Products	9	792
2833	Medicinal Chemicals	3	21
2834	Pharmaceuticals	78	8,195
2841	Soap and Detergents	49	4,208
2842	Specialty Cleaners	71	2,080
2843	Surface Active Agents	8	226
2844	Perfumes, Cosmetics	39	2,274
2851	Paints, Varnishes	98	3,921
2861	Gum and Wood Chemicals	1	32
2865	Cyclic Crudes, Dyes	10	379
2869	Industrial Organic Chemicals	37	977
2873	Nitrogenous Fertilizers	13	691
2875	Fertilizer, mixing only	55	439
2879	Pesticides	17	1,069
2891	Adhesives and Sealants	36	832
2892	Explosives	6	521
2893	Printing Ink	34	862
2895	Carbon, Black	3	245
2899	Miscellaneous Chemical Products	103	2,962

Opportunities to reduce the generation of liquid industrial and hazardous wastes are both widespread and diverse in the chemical industry. Waste abatement through the development of alternative processes and substitute products has effectively removed the introduction of some high hazard and low volume chemicals from the environment, (e.g. some organic dyes and pesticides). This level of waste prevention is naturally very process specific and often capital intensive to effect. Opportunities for waste reduction are often more generally applicable. Waste segregation, dry collection of spills, constraints on washwater use, and other simple housekeeping practices can effect a very substantial reduction of waste volume. Any improvements in waste segregation or reductions in waste volumes can, in turn, greatly enhance the practicality of the reuse or recycling of wastes. These opportunities can take the form of recovered products or raw materials for reuse or recycling in-plant, or improved economics for their applications at other plants.

4.2 MAJOR PROCESSES, WASTE STREAMS AND REDUCTION TECHNIQUES

The following sections contain brief descriptions of the production processes, wastes generated, and applications of waste reduction technologies in several chemical industry sectors. The examples presented demonstrate the great diversity of waste problems and opportunities in this industry group.

4.2.1 INDUSTRIAL INORGANIC CHEMICALS (281)

The industrial inorganic chemicals group includes firms engaged primarily in manufacturing basic industrial inorganic chemicals. The greatest proportion of production and employment in the group are for chemicals such as chlorine, caustic soda, soda ash, sulphuric acid and hydrochloric acid. These commodities are mainly used as basic materials for a wide range of industries, e.g. pulp and paper, metal refining, oil refining, etc. In addition to these bulk chemicals, a number of smaller industries produce lower volumes of specialized chemicals.

The industrial inorganic chemicals group is divided into four classifications, as shown below.

2812	Alkalies and chlorine
2813	Industrial gases
2816	Inorganic pigments
2819	Industrial inorganic chemicals, not elsewhere classified.

Chloro-alkali plants are the largest on average amongst the inorganic chemical industry in Ontario. This industry sector has received considerable attention in the past relating to toxic wastes, and is presented below as an example of waste generation and waste reduction in the industry group.

Industrial gases, (e.g. acetylene, nitrous oxide, oxygen, nitrogen) are produced at several locations in Ontario. Acetylene production is the most important of these in terms of waste production. Considerable quantities of lime sludge are generated through the reaction of calcium carbide with water to form acetylene. Production of most of the other gases generally results in negligible amounts of waste.

SIC2816 consists mainly of firms manufacturing pigments derived from minerals. Many of thes pigments contain toxic heavy metals, (e.g. chromium, lead, zinc) and hence, wasted materials and treatment sludges are of concern. Ontario inorganic pigment producers are quite small on average.

Industrial inorganic chemicals, not elsewhere classified, is a very diverse grouping. Some products are toxic compounds, e.g. chromic acid and cyanide, which produce hazadous residuals. Many, however, are relatively benign, e.g. salt cake, alum, etc. Hazardous process wastes from inorganic chemical manufacture are generally due to toxic components in off-spec product, intermediates and treatment sludges.

Alkalies and Chlorine 2812

Processes

Chloro-alkali industries produce chlorine, sodium hydroxide, sodium chlorate and hydrogen gas from solutions of sodium chloride (brine). In some cases the hydrogen and chlorine are used captively in petrochemical production, (e.g. vinyl chloride). Two production processes are in common use, viz. the mercury cell and diaphragm cell.(3)

The mercury cell process consists of two stages, the elctrolyzer and the denuder. In the electrolyzer, mercury acts as the cathode and flows concurrently with the brine. Chlorine is liberated at the graphite anode and sodium combines to form an amalgam at the cathode. In the denuder, the amalgam becomes the anode, forming caustic soda and hydrogen as products, and free mercury which is returned to the electrolyzer. Spent brine is returned for brine purification.

Wastes

In the mercury cell process, the major wastes are brine mud (often contaminated with mercury), spent sulphuric acid from drying chlorine, caustic filter solids, sodium hypochlorite from absorption of tail gases, and compressor oils.

Waste Reduction Technology

Brine muds have been treated with the waste sulphuric acid and sodium hypochlorite to effect the recovery of residual mercury. The sodium hypochlorite has been sold to pulp mills for bleaching. Mercury has been recovered by a patented process which employs reduction of mercury to the metal by sodium borohydride.

4.2.2 PLASTICS AND SYNTHETICS (282)

SIC group 282 includes manufacturers of plastic materials, synthetic resins and rubbers, and cellulosic and manmade fibres. It excludes those firms which primarily compound purchased resins for the extrusion or weaving of plastic or rubber products.

There are two major divisions of processes employed within this SIC group, viz. polymerization and spinning. Companies in SICs 2821 and 2822, manufacturers of plastic materials and resins, and synthetic rubber respectively, are the users of polymerization processes. Spinning in this industry group is carried out by companies in SICs 2823 and 2824, which include industries primarily engaged in the production of bulk man made cellulosic and synthetic-organic fibres respectively. Companies in SIC 2824 can also employ polymerization processes for large scale captive use for the direct production of fibre, especially nylon and polyester.

In Ontario most production of plastic resins, rubber elastomers and fibres is centred in a relatively small number of large companies. Some of these larger firms are the only one or two major producers of these commodities, (e.g. nylon, polyethylene, PVC).

There are three broad generic types of polymerization processes based on the type of carrier or solvent employed, viz.

Polymerization Process	Carrier
Suspension or emulsion	Water
Solution	Organic solvent
Bulk	Excess monomer

These processes employ most or all of the following steps:

- Storage of monomer(s), carriers and/or catalysts.
- Feeding of materials to the polymerization reactor.
- Polyerization reaction.
- Monomer recovery.
- Carrier separation.
- Processing of the polymer.

In addition to the above classes of polymerization, descriptions of the industry which are very important to waste generation include the nature of the polymer, i.e. thermoplastic or thermoset, and the nature of the polymerization reaction, i.e. continuous or batch.

The major waste stream from virtually all polymerization processes is off-grade product. Whether this poses a serious disposal problem is dependent upon the material. Still bottoms, derived from solvent or monomer recovery, and spent adsorbents from their conditioning, are often significant and problematic wastes. Spent catalysts, waste oils and wastewater treatment sludges are other wastes common to polymerization processes.

Plastics and Synthetic Resins (2821)

Processes

Plastics and synthetic resin industries are those which convert basic monomers and/or intermediates into non-vulcanizable polymers. There are several different groups of polymers and each may have several techniques for its manufacture. The major polymers are low and high density polyethylene, polystyrene, PVC, phenolic resins, polypropylene, polyesters and urea resins. Many of these industries, notably those producing polyolefins, operate on a very large scale adjacent to and in inter-relation with petrochemical plants. Other polymer producers are integrated with plastic fabricating operations.(4, 15)

Polyolefin production (by the Ziegler process) and phenolic resin manufacture are employed here as illustrative examples of thermoplastic and thermoset plastic manufacture, respectively.

The Ziegler process is a solution polymerization process used to make high density polyethylene, styrene, butadiene rubber, polypropylene and other rubbers and plastics. The Ziegler process consists of six basic steps:

- the monomer is combined with a catalyst (often titanium trichloride) in a solvent in a batch or continuous vessel;
- the polymer forms and precipitates from the reaction mass;
- the solvent and unreacted monomer are subsequently volatilized and recycled;
- the polymer slurry must be washed with aqueous alcohol to remove the catalyst which precipitates;
- the aqueous alcohol is then removed by distillation for reuse;
- the polymer crumb undergoes steam stripping, filtration, drying and it is then pelletized in a series of finishing operations.

Phenolic resin production is typical of that for several other non olefinic resins (e.g. alkyd resins, amino resins, epoxies etc.) which use relatively small simple batch reactions.

Phenolic resins are produced by the polymerization of phenol and formaldehyde in a temperature controlled batch reactor (the pH, temperature and duration of the polymerization process can be varied to produce various forms of phenolic resins). The polymerized product is distilled, dehydrated or rinsed depending upon the specific form, (e.g. varnish, powder, resin, etc.).

Wastes

Many kinds of liquid and solid wastes may be generated from plastics and resin manufacture. The cited examples of the Ziegler process and phenolic resin production are used to illustrate the variety of wastes produced by this industry sector.

Polyolefin production by the Ziegler process generally yields distillation tars from solvent recovery, sludges from the setting of spent titanium catalysts and off-specification product. The aqueous stream from alcohol recovery is the major wastewater stream.

Phenolic resin manufacture generates high strength wastewaters wastewaters contaminated with phenol and other organics driven off during distillation. Spent filter media is a potential source of solid waste. Off-specification product is a fairly common waste with most plastic manufacturing.

Waste Reduction Technology

Large scale plastics and resin plants which are a part of an integrated petrochemical facility have an excellent opportunity for maximum resource utilization and hence, waste prevention. Thermoplastic resin (e.g. polyolefin) production generally lends itself to the recovery of most spilled and off-specification product. Thermoset resin production does not generally have this advantage. Spent solvents and oils are often recovered and recycled. Liquid organic wastes and organic sludges may be used as fuels.

Synthetic Rubber (2822)

Process

Synthetic rubber (vulcanizable elastomers) are produced from petroleum or natural gas monomers, other intermediates, (e.g. styrene, butadiene, ethylene, propylene) and extenders, (e.g. carbon black and oil). Most synthetic rubber production is made in high volume to produce liquid (latex) or solid (crumb) product.(5)

Three types of processes are employed; viz. solution, emulsion and slurry. Generally each of these processes incorporate the following three basic operations, polymerization, solvent recovery and refinishing.

The solution crumb process is similar to that employed for polyolefin production by the Ziegler solution polmerization process outlined above under plastics and synthetic resins.

The emulsion crumb process is employed on a large scale, generally as continuous or batch continuous operations. The emulsion crumb process consists of six basic steps; monomer storage, caustic wash, polymerization, monomer recovery, coagulation and finishing.

Monomers generally have an inhibitor added to prevent premature polymerization while the monomer is in storage. These inhibiters must subsequently be removed from the monomer by washing with a caustic solution. Washed monomers, together with catalysts, soaps and other additives, are mixed in an aqueous phase to form a dispersion of polymerized rubber, called a latex. The crude latex still contains considerable quantities of unreacted monomers. The monomers are recovered by vacuum or steam distillation, cleaned by adsorption, condensed and recycled. Latex, after monomer recovery, is coagulated through the addition of acid, to convert soaps to fatty acids, and brine. Coagulated rubber particles (crumb) are then screened from the coagulation liquor. Hydrocarbon oil (oil extending) or carbon black (master batching) are often added at the coagulation stage. Recovered crumb is rinsed and dried before shipment or further processing into products on site.

Latex production processes are similar to those used for emulsion crumb production except that the latex is not coagulated nor rinsed and dried. Also, polymerization is more complete, removing the need to recycle monomers, although light and heavy residual monomers must be removed by similar distillation processes.

Wastes

Considerable quantities of wastewater are produced during synthetic rubber production, including spent caustic washwater and aqueous condensate from solvent separations, and equipment and reactor washdowns. Removal of suspended solids from these streams is often the major source of solid waste. Wastewaters may be highly contaminated with dissolved organics and metallic catalysts and may yield sludges when treated for their removal. Excess oil recovered from wastewaters is another waste source commonly present. Coagulation liquor overflow is a major source of contaminated brine from the emulsion crumb process.

Waste Reduction Technology

Waste reduction techniques used by synthetic rubber manufacturers include waste segregation (e.g. separate pits to treat coagulation and master batching wastes), dry solvent removal by extrusion from the polymerization "cement", and solvent recovery during excess monomer recycle. Oily wastes produced during excess monomer recovery may also be recovered, recycled or used as a fuel.

4.2.3 DRUGS (283)

The drug industry is divided into three SIC codes.

2831 Biological Products
2833 Medicinal Chemicals and Botanical Products
2834 Pharmaceutical Preparations.

Industries in the first two classifications are the producers of basic pharmaceuticals derived from animals and micro-organisms (2831) and plants and synthetic chemicals (2833). SIC 2834 consists of firms which primarily compound or fabricate dosage forms of active ingredients supplied by the others.

In Ontario, almost all biological products are produced by one firm which manufactures blood fractions, insulin, etc. There are also very few firms producing medicinal chemicals. The Ontario drug industry is dominated by a number of firms of various sizes which compound dosage forms, using imported active ingredients. Hence, the description below of pharmaceutical preparation is representative of most activity in the industry in Ontario.

Pharmaceutics (2834)

Processes

Most Ontario firms involved in the production of pharmaceuticals are formulators. Very few bulk pharmaceutical active ingredients are made in Canada.(6) Formulators produce dosage forms of pharmaceuticals as tablets, capsules, liquids or ointments. In each case, the active ingredients are: (i) mixed with fillers or water (for liquids); (ii) measured into dosage lots; and (iii) packaged. Tablets are formed in a tablet press and sometimes coated. Capsules are produced from molten gelatine. Liquid dosage forms for injection must be sterilized before packaging.(7)

Wastes

Wastes from pharmaceutical formulation commonly include wash waters, filtered dusts or wet scrubber waters, spills, laboratory wastes, and returned or off-specification product.

Waste Reduction Technologies

The active ingredients of pharmaceutical preparation are typically very expensive and hence, unnecessary losses are not likely. On the other hand, the quality constraints are so rigorous that any suspicion of product contamination requires that the material be disposed. Recycle or reuse of pharmaceuticals is very unlikely, due again to quality control requirements.

4.2.4 CLEANING AND TOILET PREPARATIONS (284)

Industries manufacturing cleaning and toilet preparations are divided into four classifications of primary activity, viz:

2841 Soap and Detergents
2842 Specialty Cleaners
2843 Surface Active agents
2844 Toilet Preparations

soap and detergent manufacturers include those producing soaps, synthetic organic detergents, inorganic alkaline detergents, and, as a by-product, refined glycerin from vegetable and animal fats and oils. Specialty cleaners are a highly diverse group of products, including household ammonia and bleach, dry cleaning preparations, and floor polishes. Surface active agent manufacturers include those firms primarily producing surface active agents for use as wetting agents, emulsifiers, and penetrants, many of which are employed for industrial purposes (textiles, leather, etc.). Toilet preparations include a very wide and diverse range of products (colognes to toothpastes).

In Ontario, most of the detergent and soap production is carried by a limited number of large multi-national firms. The manufacture of specialty chemicals is predominantly carried out in small firms. Relatively few primary manufacturers of surface active agents are located in Ontario. Toilet preparation manufacture is the primary activity of a number of medium to large multinational firms in Ontario. Most of the manufacturing in this sector consists of blending and compounding active ingredients obtained elsewhere.

The soap and detergent industry is outlined in the following section.

Soap and Other Detergents (2841)

Processes

Soaps are the salt and fatty acid derivatives of natural fats and oils. Soap manufacturers employ some or all of the general processes (described below) depending upon the raw materials used and the products being made. Batch kettle soap production (more common for smaller operations) in which fats are refined (often by activated clay filtration) and the soap boiled with salt and caustic to yield crude soap and dilute crude glycerine. Low grade fats and oils may be upgraded to higher value products by hydrolytic splitting at elevated temperature in the presence of a catalyst into fatty acids and glycerine. Fatty acid neutralization is a process by which fatty acids are reacted with caustic to produce crude soap. Glycerine from kettle soap production is recovered by neutralization with hydrochloric acid, treatment with alum to remove residual soaps as precipitate and, finally, evaporation to concentrate the glycerine and recover the salt (which is recycled to kettle soap production). Concentrated glycerine is further processed by distillation to recover the finished product. Crude soap from kettle or fatty acid production is further mixed, milled, etc., to produce flake, bar and liquid products.

Detergents are manufactured by various sulphation and sulphonation routes from petroleum derivatives. In one common route, oleum is mixed continuously with an alcohol and/or alkyl benzene in a reactor wherein the alcohol sulphate or alkyl benzene sulphonate is quickly formed. Reaction products are cooled and mixed with water. The dilute sulphuric acid is then separated and the sulphonated/sulphated material subsequently neutralized with caustic. The neutralized product is then spray dried to form detergent powders, or mixed with other ingredients to form liquid detergents.(8)

Wastes

Soap production yields filter clays from fat refining, distillation bottoms from glycerine bottoms, spent catalysts (often heavy metals) from fatty acid manufacture, and unrecovered raw materials and intermediate and final products. With the exception of filter clays, all of these wastes are often found in a single dilute wastewater stream.

Detergent production by oleum sulphonation and sulphation yields spent sulphuric acid as its major waste stream. Raw, finished and intermediate material spills, fume scrubbing wastewater and reactor wash waters are other wastes generated.

Waste Reduction Technologies

Greatly enhanced potential for material recovery from wastewaters is reported to be realized when water use is lowered. Glycerine, fat, and surface active agents are recovered for reuse. Water use can be reduced by such measures as separation of cooling from process water, employing dry waste collection, and using air instead of water to blow out filling lines.

Spent sulphuric acid from detergent manufacture can often be reclaimed by returning it to the manufacturer or, alternatively, it can be reused by other industries, for example, for phosphatic fertilizer production.

4.2.5 INDUSTRIAL ORGANIC CHEMICALS (286)

The industrial organic chemicals industry group includes the following sectors:

2861 Gum and Wood Chemicals
2865 Cyclic Crudes, Dyes and Pigments
2869 Other Industrial Organic Chemicals

The gum and wood chemicals industry consists mainly of firms whose primary activity is manufacturing products from the distillation of hard and soft woods, e.g. pine oil, turpentine, charcoal, etc. The cyclic crudes, dyes and pigments classification contains manufacturers whose principle products are derivatives of coal tars and heavy oils and the synthesis of aromatic derivatives. The producers of miscellaneous industrial organic chemicals include firms primarily engaged in the manufacture of a broad range of products ranging from synthetic acetic acid to vinylacetate.

The gum and wood chemicals industry is very small in Ontario, having been made largely redundant by the growth of petroleum based chemicals. Turpentine and rosin are produced in Ontario. The major unit operations employed for making turpentine and rosin include countercurrent solvent extraction followed by steam extraction of wood chips. The extract is then concentrated in a series of evaporators. Vapours from intermediate evaporators is fractionated to produce oils and turpentines. The residue from the final evaporator is crude rosin, which may be further treated by selective solvents and absorbents to produce light rosins.

Wastes from turpentine and rosin production include fractionation tower bottoms, spent absorbents, and unmarketable fractions.

Raw materials employed in the SIC 2865 are mainly benzene derivatives, e.g. analine, napthalene, etc. these are then converted into more complex intermediates and finally, into the desired dyes or pigments. Originally, the basic raw materials were produced within this industry sector from coal and heavy oils. However, most production now employs purchased materials. This is not a major industry in Ontario, however, it employs many processes and produces wastes which illustrate the situation of many organic chemical industries. It is further described below.

The miscellaneous industrial chemical industry employs a great number of processes and raw materials which produce a variety of residuals and other wastes.

Organic Dyes and Pigments (2865)

Processes

Organic dyes and pigments represent a large body of compounds which are produced by a number of processes from various purchased chemicals, usually aromatic hydrocarbons (benzene, toluene, naphthalene, etc.). These chemical intermediates undergo a number of operations to form the various products. A single firm is likely to produce several related products, using different chemical substitutions. Being high value products, dyes and organic pigments are generally produced in relatively small lots through batch operations.(10)

Wastes

A myriad of different wastes are generated by organic dye and pigment manufacture, reflecting the many products and processes. Solid wastes generated include distillation residues and particulate matter recovered from gaseous emission sources. Liquid wastes, however, are usually more serious. These wastes include brines, reaction by-products, filtration media, and various heavy metal catalysts. It is notable that some chemical intermediates in this industry are highly toxic, (e.g. benzidine and 2-naphthylamine).

Waste Reduction Technology

The complex nature of this industry and its typically small scale of production make waste prevention problematic. In some cases, less toxic intermediates have replaced formerly used compounds. Also, the production of some dyes has ceased altogether because of environmental problems.

4.2.6 ORGANIC COATINGS

This industry group has been developed here to reflect the similarity in processes and waste generation of three SIC segments, viz.

2851 Paints, varnishes, ...and Allied Products
2891 Adhesives and Sealants
2893 Printing Ink

Most of the industries located in Ontario whose primary activity includes the manufacture of the organic coatings noted above, are relatively small. Most of these plants produce batch losts of various grades and types of coatings by mixing ingredients purchased off-site. The products are generally either solvent or water-based suspensions, slurries or pastes. Wastes from these operations are mostly related to equipment cleaning.

A notable exception to the above generalizations are those firms which produce adhesives from animal by-products. These firms often discharge considerable quantities of organic wastes. However, these are non-hazardous and amenable to conventional waste treatment.

The paint and allied products and the printing ink industries are briefly described in the following sections.

Paints And Related Coatings (2851)

Process

Paints are generally classified as either solvent or water base. Most paint manufacturers will produce many types of paints, often in both of these broad classes. Three major steps are typically employed: (i) mixing and grinding; (ii) tinting and thinning; and (iii) filling. In mixing, portions of pigment, binder and vehicle are combined to form a paste. This is subsequently ground in a mill. Thinning and tinting is performed in stirred tanks into which further binder vehicle and other constituents are added. The mixture subsequently is filtered and packaged. Grinding is generally not required for water based paints.(9)

Waste

Typically, a considerable amount of paint remains in tanks after draining, which must be removed before subsequent batches are prepared. A solvent or alkali wash is used with solvent based paints to remove this "clingage", resulting in a sizeable waste stream. Similarly, water base paints are removed by water washes.

Additional wastes include spoiled batches of product.

Waste Reduction Technology

Solvent wash solution is generally used in the next batch of compatible paint, or collected and redistilled on-site. Water washes may also be combined with compatible paint batches.

The amount of wastewater generated can be reduced by using fine, high pressure water sprays, rather than hoses, to clean tanks and other equipment, or by sealing floor drains, to ensure that floors are not "hosed" down.

Another simple but effective waste reduction technique is to squeegee as much residual paint as possible from vessel walls before wash down. Many industries reuse their wastewater or solvents until it becomes too highly contaminated, while employing a small amount of virgin material for the final rinse.

Inks (2893)

Processes

Inks are formulated in batch vessels (tubs) in which the major ingredients (vehicles, pigments and dryers) are mixed. Most inks are formulated from prewetted pigments and can be made in one vessel; others need additional dispersion with further milling. Pigments can be either organic or inorganic (often heavy metal) compounds. Most inks are solvent or oil base, though some water base is used.(13)

Wastes

Most waste generated in ink manufacture is related to tub cleaning. Solvents or caustic solutions are used to clean solvent base inks and caustic or water is used to clean water base inks. Often, plants using a caustic wash system follow with a water rinse.

Off-specification product and packaging material are other sources of waste.

Waste Reduction Technology

Waste reduction is effected in ink formulation by modifying tub cleaning techniques and employing recycle. Significant waste reduction is possible by using a squeegee to remove most of the ink residue before tub washing. The use of fine, high pressure sprays can also reduce the volume of water used to clean equipment. In small operations, industrial wipers can be used to partially or completely remove residues from equipment. Sealing off floor drains is a common technique to prevent the hosing down of equipment and spills, relying instead on dry collection or cleaning.

Most ink formulators recycle some of their solvent or caustic washes. The solvent or caustic is generally reused until too highly contaminated. Where water is used as a final rinse after caustic washing, a portion or all of the rinse water may be reused as make up for the caustic holding tank. Solvents are often redistilled on-site or by a solvent recycling firm.

Portions of solvent or water washes are generally reworked into subsequent ink batches where possible.

4.2.7 Agricultural Chemicals (287)

The agricultural chemicals group consists of four industry classifications, viz.

2873 Nitrogenous fertilizers
2874 Phosphatic fertilizers
2875 Fertilizers, mixing only
2879 Pesticides and other agricultural products

The first two classifications engage in the production of basic fertilizers. These industries are often large-scale operations, which are located close to supplies of raw materials, (i.e. natural gas, sulphuric acid and phosphate rock). The latter two classifications include firms which formulate end use agricultural chemicals. These firms are mostly small in size and they predominate the industry group in Ontario.

Phosphatic fertilizers are produced from imported phosphate rock. In the wet acid process, phosphate rock or concentrate is reacted with sulphuric acid to produce dilute phosphoric acid and gypsum. The gypsum is filtered off and the dilute phosphoric acid concentrated in vacuum evaporators. Off-gases may be treated by scrubbing equipment to yield H_2SiF_6 as a by-product.

Gypsum produced by the wet acid process is a major disposal problem for the industry. Phosphoric acid production is often related to the smelting of sulphide ores, from which sulphuric acid, another major feedstock for fertilizer production, is derived.

The key step in nitrogenous fertilizer production is synthesis of ammonia from nitrogen and hydrogen. Hydrogen is most commonly produced by the steam reforming process, by which purified natural gas is reacted over a nickel catalyst with air and steam to form hydrogen and carbon oxides. Carbon monoxide is subsequently converted to carbon dioxide over iron and zinc catalysts. The carbon dioxide is then absorbed, leaving essentially pure nitrogen and hydrogen. Ammonia is produced from the hydrogen and nitrogen by compressing these gases, combining them with recycled synthesis gases, (after separating the condensed amonia), and then passing the gases through an iron oxide synthesis catalyst. Ammonia from this process is the raw material for the production of most nitrogenous fertilizers.

Major wastes from nitrogenous fertilizer production include sludges from the treatment of condensates and off-gas scrubber solutions, and contaminated catalysts and absorbents.

Ammonium sulphate production is often a form of waste utilization. Off-gases from coke ovens which contain ammonia can be reacted with waste sulphuric acid from steel production to produce this fertilizer.

The mixed fertilizer industry generally consists of smaller plants located near to markets for the fertilizer, rather than near to the sources of raw materials. Intermediate materials produced by primary fertilizer industries are dissolved and reacted or blended by mixing to produce mixed fertilizers of composition suitable to local needs.

Generally, little waste other than off-spec. product, would be expected from this industry classification.

The pesticides and other agricultural chemicals manufacturing classification includes those firms which formulate and prepare ready-to-use agricultural and household pest control chemicals. These firms use technical grade chemicals and concentrates obtained from industrial organic and inorganic chemical manufacturers.

Wastes from the formulation of pesticides and other agricultural chemicals include solutions from equipment cleaning and returned or off-spec. products or raw materials. The pesticides industry is further described in the following subsection.

Pesticides (2879)

Processes

Most of the industries listed under this category are compounders of agricultural products who do not produce the bulk pesticides which they market. Many different kinds of pesticides are in use and represent several generic types of organic chemicals, including organophosphates, carbamates, chlorinated hydrocarbons, triazines, etc. Processes employed to manufacture pesticides are highly varied in both type and scale and, indeed, are often proprietary. For the sake of illustration, the relatively simple example of the production of 2,4-D is used. This pesticide is formed by a three step operation; (i) reaction of chloracetic acid with caustic; (ii) the product is neutralized with 2,4-dichlorophenol and condensed; and (iii) the product is neutralized with HCl to form, 2,4-D and salt and the product is recovered and dried.(11)

Wastes

It is impossible to generalize about the wastes from the pesticide industry. The example of 2,4-D is again used to illustrate the range of wastes generated. Relatively large amounts of hydrochloric acid, caustic and organics are generated from acidification, washing and phase separation respectively. Chlorophenols and other chlorinated organics are also discharged as a result of incomplete reaction and formation of chlorinated by-products.

Waste Reduction Technology

Given the toxicity and high value of pesticides, waste reduction, recovery and recycle are expected to be widely practiced in this industry. The example of 2,4-D is used to illustrate the situation.

The salt by-product from 2,4-D production is generally recovered, as is unreacted dichlorophenol which is returned to the condensation reactor. Dusts resulting from the manufacture are also collected and recycled at some locations.

4.2.8 MISCELLANEOUS CHEMICAL PRODUCTS (289)

Several chemical products fall outside of the groups presented above. These include:

2892 Explosives
2895 Carbon black
2899 Other chemical products

Two other industry sectors, viz. gum and wood chemicals (2891) and printing inks (2893), are described above in other groups, i.e. industrial organic chemicals (286) and organic coatings, respectively, due to similarities in their waste characteristics with those industry sectors.

The carbon black and explosives industries are outlined below as further examples of the diversity of waste generation and reduction in the chemical industry.

Explosives (2892)

Processes

Explosives come in many forms and types depending upon the use required. Most explosives are nitrated organic compounds. Trinitrotoluene (TNT) illustrates explosives manufacture. TNT is made in three steps; nitration, purification and finishing. Nitration is carried out in a series of counter current vessels with toluene entering at the upstream end and concentrated nitric acid entering downstream. Purification consists of washing the crude TNT counter currently with water and then soda ash is added to neutralize, followed by sodium sulphite to remove isomers. Finishing the TNT slurry entails melting the TNT and removing the remaining water before final flaking and packaging.(12)

Waste

Wastewaters generated by explosives manufacture are often very acidic and contaminated with organic compounds, including product. Solid wastes are mainly dusts and packaging material contaminated with explosive.

In TNT production, wastewater from fume scrubbing is often treated with activated carbon, resulting in a solid waste.

Waste Reduction Technology

Spent acid from nitration is generally recovered. Wastewaters from TNT purification are generally recycled to the nitration step, in the case of washwaters, or are sold to the pulp and paper industry or incinerated, in the case of the sulphite rinse waters. Recovery of explosives themselves is naturally problematic. Most solid wastes are disposed of by open burning.

Carbon Black (2895)

Processes

Most carbon black is manufactured by the furnace process. It entails the partial combustion and thermal cracking of a liquid hydrocarbon source. The furnace exit gases are quenched and the carbon black removed by filtration.(14)

Wastes

Little liquid or solid waste is generated during carbon black manufacture. Off-specification product and filter fabric are occasionally discarded.

Waste Reduction Technology

Off-specification material may be blended into product. Any oily wastes may be used as raw material for carbon black production.

4.3 APPROACHES TO WASTE REDUCTION UNDERTAKEN IN ONTARIO AND CURRENT DISPOSAL PRACTICES

General

Table 4-2 summarizes the waste streams from seventy chemical industries which responded to the waste abatement survey. The last column shows that seventeen of the respondents did not generate wastes considered to be applicable to OWMC. Many of these industries did generate quantities of non-hazardous solid wastes, e.g. plastics and paper, and conventional sewered wastes. (e.g. neutralized acids or bases.) Most of the non-waste generators were primarily distributors of chemical products, notably, pharmaceutical (2831 and 2833), organic chemical (2869) and miscellaneous chemical (2899) companies. The greatest number of waste streams considered applicable to OWMC were primarily organic liquids or sludges.

Table 4-3 summarizes the fates of the various waste types. Solvents and oily wastes had the highest degree of reuse or recycle, at 65% and 60% of the reported waste streams respectively. In terms of all the waste streams, reuse and recycle accounted for 28%. Off-site disposal was the fate of about one-half of the wastes.

Recycle of waste for the original purpose, was mostly practiced for solvents. Recycle was also practiced in a closed cycle process water system and with some relatively valuable solid wastes. Contamination, dilution and small waste volumes were commonly noted barriers to recycle.

Reuse of wastes for other purposes was reported most often for oily wastes. The most common type of reuse of organics was as a fuel. Three of the organic and all of the solid and aqueous wastes reused, were reused as raw materials for other processes, (e.g. sulphuric acid from sulphonation reused for fertilizer production).

The ultimate fates of wastes receiving off-site disposal were not known to many of the survey respondents. The disposal of most wastes was contracted to a commercial waste hauler. It is possible that some of these waste streams were reused or recycled, especially oily and spent solvent wastes.

The means of on-site disposal was incineration for two streams, landfilling for another two, and chemical destruction for one waste. A significant number of wastes were stored on-site by the survey surveyed companies. However, most of these waste streams were comparatively small.

TABLE 4-2
WASTE STREAMS GENERATED BY COMPANIES SURVEYED IN THE CHEMICAL MANUFACTURING INDUSTRY

SIC Group	No. of Interviews	Waste Type							No Applicable Waste
		Solvents	Oils	Liquid Organics	Organic Sludges	Other Organics	Aqueous Solutions	Misc. Solids	
2812 Alkalies and Chlorine	2		1	1				2	
2813 Industrial Gases	3	2	2		2				
2816 Inorganic Pigments	2		1		1			3	
2819 Industrial Inorganic Chemicals	1					1			
2821 Plastics, Synthetic Resins	1	1	2						
2822 Synthetic Rubber	2			5			2	1	
2823 Cellulosic Fibres	2								2
2824 Synthetic Fibres	3		2	1				1	
2831 Biological Products	1			1					1
2833 Medicinal Chemicals	4					1			3
2834 Pharmaceuticals	5	1		1		4			
2841 Soaps and Detergents	3						1		1
2842 Specialty Cleaners	3	1		2		1			
2843 Surface Active Agents	2	1		4					1
2844 Perfumes Cosmetics	2	1		2	1				
2851 Paints, Varnishes	3	2			4				
2865 Cyclic Crude Dyes	4	1		2				1	
2869 Industrial Organic Chemicals	4		1	1			1		2
2873 Nitrogenous Fertilizers	1						2	3	
2875 Fertilizers (Mixing only)	1							1	

TABLE 4-2 CONTINUED

WASTE STREAMS GENERATED BY COMPANIES SURVEYED IN THE CHEMICAL MANUFACTURING INDUSTRY

SIC Group	No. of Interviews	Waste Type							No Applicable Waste
		Solvents	Oils	Liquid Organics	Organic Sludges	Other Organics	Aqueous Solutions	Misc. Solids	
2879 Pesticides	4	1				7			1
2891 Adhesives and Sealants	4	2		2	2	2			1
2892 Explosives	1					2		1	
2893 Printing Ink	4	3		1	2		1	1	
2895 Carbon Black	2		1						1
2899 Miscellaneous Chemical Products	6	1	2						4
TOTAL	70	17	12	22	12	18	7	14	17

TABLE 4-3
REPORTED FATE OF WASTE STREAMS GENERATED BY COMPANIES SURVEYED IN THE CHEMICAL MANUFACTURING INDUSTRY

	Fate (No. of Waste Streams)					
Waste Type	On-site Waste Disposal	Off-site Waste Disposal	Recycle	Reuse	Sewer	Stored On-site
Solvents		4	10	1		2
Oily Wastes		5		7		
Liquid Organic Wastes		16		4	1	1
Organic Sludges		8				4
Other Organic Wastes	1	12			1	4
Aqueous Solutions	1	4	1	1		
Miscellaneous Solid Wastes	3	3	2	3		3
TOTAL	5	52	13	16	2	14

Waste Solvents

Spent solvents are a common waste generated by many industries. Fifteen chemical industries surveyed, representing a cross-section of produced types and plant size, reported a total of seventeen solvent wastes. All of the spent solvents were derived from clean-up type operations, often from batch processes. Several solvent types were reported, including alcohols, ketones, alkanes and chlorinated compounds.

The fate of these waste streams are summarized below:

	No. of wastes	Tonnes/year
Disposal off-site	4	180
Recycle by contractor	6	340
Reuse off-site	1	2
Recycle off-site	2	50
Recycle on-site	2	4
Stored	2	0.1

Successful waste reduction was noted by several respondents. A number of industries observed substantial reduction through in-plant housekeeping improvements. Barriers to further reduction were generally the quality required by the various cleaning operations.

Solvents were recovered on-site by distillation, according to two respondents. Two other plants had their rinse solvents recovered by sister plants. Another industry delivered its spent acetone directly to another company which used it as a fuel. Complex mixtures present in the solvent wastes were noted as the main barrier to recovery of larger waste streams. Too small a volume to permit recovery on-site was claimed for other wastes. One firm plans to redistill on-site two wastes presently being disposed.

Off-site solvent recovery conducted by recycling firms was applied to a large by-product methanol stream and a small quantity of trichloroethylene. Four other industries used solvent recyclers on a "toll" basis, wherein they paid the recycler a fee for redistilling their spent solvents. Similar barriers to solvent recovery, viz. complex mixtures and low volume, were the barriers cited for not applying waste recycle on-site.

Four waste streams are currently being disposed off-site. Two larger waste streams are being shipped to Tricil for incineration. These are scheduled to be greatly reduced by redistillation on-site. The other two wastes are much smaller and are picked up by waste haulers. Their destination is uncertain; however, it is likely that they are recovered by solvent recyclers.

Oily Wastes

Used oils are a common waste of many industry groups. Ten industries reported a total of 12 waste oil streams. Most of the wastes originated as spent lubricating oils in relatively small quantities.

The fates of these wastes are summarized below:

	No. of wastes	Tonnes/year
Disposal off-site	5	117
Reuse on-site	2	911
Reuse off-site	5	12.3

Waste reduction opportunities are somewhat limited for oily wastes generated from lubricating operations due to the quality constraints of these roles. Most of these oils were used in compressors. An exception was a specialty chemical manufacturer who used paraffinic oils to clean equipment. This industry managed to reduce its waste generation by over 90% by reusing the "dirty" oils for initial clean-ups before final use of virgin material.

Reuse of waste oil was employed by two survey respondents. One, a very large integrated petrochemical manufacturer, used all its waste oils as a boiler fuel. The other industry used waste compressor oils as a feed stock for carbon black manufacture. Another plant intends to utilize its waste oil emulsion (80% water) as a fuel to supply process heat. Barriers to reuse of oily wastes noted by respondents were a lack of on-site demand for fuel oil and, where the demand existed, contamination of the oils with solids or toxic components which precluded their use at that site.

Several respondents had their oily wastes picked up by waste haulers, whom they thought recovered some value of the oils. Higher quality waste oils (mostly from compressors) were likely recovered for other lubricating applications. One industry supplied its waste oil to a local fuel oil distributor who, in turn, blended it for use by his clients.

Barriers noted to recycle or reuse by contract recyclers were, contamination with solids or toxic compounds and, in the case of a light oil emulsion, rapid biodegradation of the oily waste in storage.

Current disposal methods of oily wastes reported by respondents were unknown to two respondents, landfilling of two wastes by a third, and incineration by a fourth. Landfilling of the two oily wastes was expected to halt shortly, to be replaced by incineration off-site for one, and reuse as a fuel on-site for the other.

Organic Liquid Wastes

Liquid organic residues, bearing toxic or flammable fractions, are a waste type often associated with the organic chemicals industry. Sixteen of the industries interviewed reported, in sum, twenty-two liquid organic wastes. These wastes were predominantly production waste by-products, (e.g. still bottoms or reaction kettle residues). Some aqueous residues from equipment wash and fume scrubbing were also reported. These wastes were often complex mixtures.

The fates of the liquid organic residues are summarized below.

	No. of wastes	Tonnes/year
Disposal off-site	16	1,500
Municipal sewer	1	-
Reused on-site	3	200
Reused off-site	1	5,500
Stored on-site	1	500

Ten of the waste streams currently being disposed of off-site were reported to have been substantially reduced to their present levels through various improvements in process operations and general housekeeping. Each of these wastes contained little water. Further improvements in waste reduction were considered unlikely, and the residuals were considered to be unavoidable by-products of the chemical processes. Four firms generated aqueous organic bearing wastes, three of which are currently disposed off-site, reported that they plan to institute dewatering, through reverse osmosis or coagulation. Another firm reported that they plan to incinerate, possibly with heat recovery, at their site within two years.

The single firm which currently sewers a fume scrubber wastewater, is planning to replace the solvent base process, which generates organic vapours, with a water base coating technique.

Three firms reported reuse of wastes on-site. One uses nonene, a waste by-product, as a fuel to raise process steam. The other two firms rework all of their latex bearing wastewaters into their various products.

One respondent reported that they deliver a large volume of phenolic bearing waste water to a neighbouring steel plant. The steel plant treats it along with their coke waste waters by liquid/liquid extraction to recover the phenol. The phenol is presently used as a fuel, owing to a soft market for phenol.

Disposal of seven of the liquid organic waste streams is by incineration at Tricil Limited in Corunna. The seven other wastes also disposed off-site are carried by waste haulers to unreported destinations. "Waste haulers" accounted for one quarter of the amount of disposed wastes.

Two liquid waste streams which are by-products of soap and cosmetic manufacture are disposed of in municipal landfills. A single firm generates a liquid distillation bottoms stream which is stored on-site in a lagoon. Any reuse or recycle of this particular waste was reported to be prevented by its going "solid" upon cooling.

Organic Sludges

The majority of organic sludges reported by respondents in the survey originated from the paints and coatings industries. The sludges were mostly derived from solvents used in clean-up operations in the servicing of batch mixing and reaction vessels. Many of the sludges thus contained residues of solvents used and portions of products, including heavy metal pigments. Nine industries, representing SIC groups 2851(2), 2891(2), 2813(2), 2844(1), and 2893(2), reported 12 organic sludge waste streams.

The fates of these sludges are summarized below.

	No. of wastes	Tonnes/year
Disposal off-site	8	550
Stored on-site	4	4

Waste reduction is achieved by most paint and ink manufacturers by careful control of operations. They report that by sequencing batch mixing operations from light to dark shades, the need to remove residues from previous batches is minimized. Clean-up operations and the waste solvents and residues they generate, are also minimized by extending production runs. Indeed, one respondent claimed that virtually no waste would be generated if they had total control over production scheduling. Present market conditions for the paint and coatings industry were noted as major barriers to effective waste reduction, because:

- inventories must be kept low,
- buyers purchase smaller lots,
- buyers purchase at short notice with immediate requirements,
- the industry can afford to lose no orders regardless of size,

One relatively large paint and ink manufacturer reported that they were able to rework portions of their spent solvent and sludge mixtures into new batches of paint by storing the residues separately. Another large paint manufacturer noted that a significant decrease in the volume of paint sludge could be achieved if the sludge were filtered to recover a fraction of the solvent, which could, in turn, be reused or recycled. The cost of suitable filtration equipment was assumed, however, to be excessive for most operations. This same respondent was also considering delivering a fraction of their waste paints and solvents to a neighbouring cement manufacturer for use as a fuel.

In contrast to larger manufacturers who appeared to have considerable awareness and experience with waste reduction, smaller companies seemed less certain of their options. This is in part evidenced by the two sludges reportedly stored on-site. A small ink manufacturer was a notable exception. They reported no sludge for disposal, through squeegeeing of batch vessels and using rags for the final clean-up.

The ultimate fate of the organic sludges was not known to most of the respondents. All reported that they were picked up by various industrial waste haulers.

Other Organic Wastes

This category, which includes nineteen waste streams from industries, is a catchall of several waste types not elsewhere discussed. Most of these wastes are essentially products of the various chemical industries, including residues from pesticide and explosive manufacture, laboratory wastes, off-specification and returned products, and a single unit of PCB waste held in storage. The distribution of wastes by SIC groups was 2819(1), 2831(1), 2834(4), 2842(1), 2879(7) and 2891(2).

The fates of these wastes are summarized below:

	No. of wastes	Tonnes/year
Disposal on-site	1	5
Disposal off-site	12	130
Stored on-site	4	30
Sewer	1	800

Most respondents noted that, as these wastes were often finished products, they usually took considerable pains to avoid the loss of valuable material. It is notable that most of these wastes accounted for small annual amounts. Measures reported by respondents to reduce waste generation included incentives to production personnel to avoid wastage and the careful recording of material loss. Barriers to waste reduction were often quality control constraints which overshadowed waste concerns. One industry representative noted that customer qualms would not permit the reuse of returned or off-specification product. Pharmaceutical firms are prohibited from repackaging their expired or returned products. Quality control laboratories were in some cases themselves the origin of wastes.

Another barrier to waste reduction reported by one respondent was the inability of their suppliers to provide various raw materials (resins, pigments, etc.) in bulk. The current operations employ drums, which result in disposal problems for the residuals in the spent drums.

Barriers noted to prevent the reuse of residues of pesticide and explosive manufacture were the inherent hazard of the material and, in some cases, the mixing of the residues of several products.

Another barrier frequently noted was that the residues were often generated at infrequent intervals and in small amounts.

Most of the respondents reported that they employed industrial waste haulers to dispose of their wastes, and in many cases they did not know the ultimate destination of these materials. Four industries stored their wastes on-site. An explosives manufacturer reported that they burned packaging material contaminated with explosives on-site and chemically treated nitroglycerin waste before dilution and sewering.

Aqueous Solutions

Seven potentially hazardous aqueous waste streams were reported by five chemical industries in SIC groups 2893(1), 2822(1), 2841(1), 2869(1) and 2873(1). Five of the wastes are derived directly from chemical processes. The other two are washwaters contaminated with heavy metals.

The fates of these wastes are summarized below.

	No. of wastes	Tonnes/year
Disposal on-site	1	6,818
Disposal off-site	4	7,800
Reuse on-site	1	?
Reuse off-site	1	?

Potential reduction of the aqueous process wastes had been considered by most of the respondents. Two inorganic salt waste streams generated by one chemical manufacturer were concentrated to just below saturation through a process modification to minimize the volume for disposal. Another firm has established a closed system for wastewater resulting from a fertilizer process, thereby eliminating waste discharge entirely from the process. Waste reduction was less advanced for the two respondents with heavy metal bearing washwaters. Both firms reported that efforts were underway to reduce the wastes by tightening up on wash procedures. The possibility was under investigation by one firm of concentrating the contaminants and hence, permitting sewer discharge or reuse of the water.

The waste stream reported as reused off-site was strong sulphuric acid resulting from sulphonation in detergent manufacture. This material is currently being reused for fertilizer manufacture.

Means of disposal were unknown for three of the aqueous wastes disposed off-site. These were taken by an industrial waste hauler. Two saturated inorganic salt wastes from one plant were shipped to the United States for disposal. One was delivered to the Niagara Falls, New York, sewage treatment plant. The other was hauled to Ohio for deep well disposal. The expense of disposal was considered very high by the respondent for these wastes. The wastes had been the subject of extensive efforts to effect reduction and to find potential markets.

Miscellaneous Solid Wastes

Several possibly hazardous solid industrial wastes were reported by the survey. Fourteen waste streams were recorded for eight industries, representing SIC groups 2812(1), 2822(1), 2824(1), 2873(1), 2895(1), 2865(1), 2875(1) and 2893(1). Several of the wastes in this grouping consisted of primarily inert solids contaminated with small amounts of toxic materials, e.g. gypsum and activated carbon with mercury, and contaminated soil, ash and rags. Other wastes reported were discarded fertilizer, spent catalysts, and mineral residues from inorganic pigment production. All but two of the wastes in this grouping are primarily inorganic materials.

The fates of these wastes are summarized below.

	No. of wastes	Tonnes/year
Disposal on-site	3	1,600
Disposal off-site	3	430
Reused off-site	3	?
Recycled off-site	3	?
Stored on-site	3	0.7

Normal production practices of improving process efficiency and preventing material loss were reported as waste reduction efforts by respondents. Generation of wastes was unavoidable in several cases, the results of inevitable contamination, (e.g. spent catalysts and activated carbon), or the limits of extraction efficiency, (e.g. mineral residues).

In cases where waste streams contained relatively valuable fractions, wastes were sold to others for reuse or recycle. Two zinc containing streams were sold for reuse as sources of trace elements for fertilizer and cattle feed respectively. Another fraction of zinc rejects were sold to a firm in the U.K.

for recycling. Off-specification fertilizer was given to local farmers by one firm. Another example of recovery was an ink compounder who used recycled industrial wipers to clean batch mixing vessels.

Spent organic catalyst was incinerated on-site by a fertilizer producer. Three relatively large volume wastes; viz. contaminated ash, soil, and activated carbon, were taken by truck for disposal off-site in landfills. Three other wastes were stored on-site. Two of these are small volume wastes and were drummed. The other was gypsum contaminated with mercury, which has been accumulating in a field for more than ten years.

4.4 POTENTIAL ROLES FOR OWMC TO ENCOURAGE WASTE REDUCTION IN ONTARIO CHEMICAL INDUSTRIES

Ontario chemical industries which responded to the survey were asked to respond to eight suggested roles OWMC might assume to promote waste reduction, reuse and recycle. These questions, together with the positive, negative and neutral responses to them are shown below. A positive or negative response was recorded if the industry contact considered that OWMC in the potential role might or might not assist them with their waste problems. A neutral response was recorded when the contact either considered that their industry did not have a waste disposal problem or was unwilling to venture a comment.

	Response from 70 Interviews		
Suggested Potential Role for OWMC	Positive	Neutral	Negative
Trained personnel to visit your plant and advise on waste reduction.	10	33	27
Mobile plant for waste reduction which could visit your plant once or twice per year, e.g. neutralization, dewatering, filters, reverse osmosis units.	11	32	27
Industry specific seminars on waste reduction.	15	33	22
Operating a waste exchange programme for waste reuse.	14	33	23
Operating recycling plants for waste streams not adequately dealt with by the private sector.	10	34	26
Arguing for improved tax incentives for waste reduction.	19	34	17
Arguing for improved legislation to facilitate waste reduction and reuse.	10	37	23
Conducting or supporting research and development on waste reduction.	18	37	15

A neutral response was obtained from approximately one half of the chemical industries which participated in the survey. The majority of these were industries which reported either very little or no hazardous or liquid industrial waste generation. Slightly more respondents were non-committal on the roles of lobbying for improved regulation and of support for research and development. In the first case, the subject of regulation tended to make the managers wary, and in the second case, a general lack of familiarity with research and development and its funding led many to defer comment.

The greatest number of positive responses to suggested potential roles of OWMC were for the conducting and support of research and development and for the lobbying of governments to improve tax incentives for waste reduction. Specific needs related by respondents for research and development were in the field of new opportunities of waste reuse by others. One large integrated multi-national chemical company felt that their resources were such that they were at the leading edge of new technology and applications for waste materials.

Tax incentives found good support from many industries contacted, without qualification. Several of the respondents, however, noted at length that they considered that the savings in material, energy or waste disposal costs should be sufficient reward in themselves. These companies tended to be those which either had effected significant, or were actively pursuing, waste reduction.

The potential roles for OWMC of operating a waste material exchange program and sponsoring industry specific seminars found relatively moderate support from the chemical industries surveyed. In terms of waste material exchange, most of the support for an OWMC role came from large industries. Two favourable respondents saw a need for assistance in finding markets for waste materials, both within and outside of Canada. Three-quarters of those responding positively to the waste material exchange role were not aware of or had not employed the Canadian Waste Materials Exchange Bulletin.

Industry specific seminars sponsored by OWMC found strongest support from the smaller industries surveyed. An aspect in keeping with the current economic climate which was noted by some respondents, was that any seminars hosted by OWMC should be cheaper than traveling outside the province to attend other seminars. Other respondents, (i.e. those from larger industries), felt that seminars operated by The Ontario Ministry of the Environment and by industry associations, (e.g. the Canadian Paint Manufacturers Association), were doing the job.

The potential roles of OWMC which entailed the most active involvement in waste reduction, viz. site visits, mobile waste reduction plants and waste recycling plants, found relatively little support from Ontario chemical industries. Several respondents from larger industries noted that they had their own pollution control expertise and hence, had no need for outsiders to advise on waste reduction opportunities. Mobile waste reduction plants, while not widely favoured, drew enthusiastic response from some industries which were presented with small but recoverable waste streams, which alone could not justify the capital cost of recovery equipment. Examples given included reverse osmosis for contaminated aqueous wastes, dewatering of voluminous sludges, and distillation of solvents.

Recovery of spent solvents was noted by some ink manufacturers as a problem, due to small volumes which made them neither attractive to private solvent reclaimers, nor sufficient to justify the purchase of distillation equipment. These industries saw a potential role for OWMC in either a mobile facility or a recycling plant accepting small lots of spent solvent.

The role which received the least positive support and the strongest negative comment was in lobbying for improved legislation to facilitate waste reduction. Most respondents could see no benefit, and considerable risk in any increased government pariticipation or interest in the field. An interesting exception was a comment by one large chemical firm who perceived that the need existed for the provincial government to suppress the development of unwanted municipal by-laws. The Mississauga anti-PCB burning by-law was noted as an example of regulation opposing waste reuse, in this case, PCB contaminated waste as a fuel in cement kilns.

When asked to volunteer any other roles for OWMC, the response fell into two groups; providing a waste treatment service, or providing an information service. In the former case, the respondents were generally looking for an alternative, or competition, to existing disposal services, which they noted as being increasingly expensive. Small waste volumes, (e.g. laboratory wastes), and major process wastes, (e.g. gypsum), were noted, as requiring alternatives to presently available disposal options.

Publication of a newsletter was seen as a potentially valuable role for OWMC to undertake. Good sources of information concerning available waste disposal and recycling services, emerging waste reduction technologies, and appropriate waste handling and storage procedures, were noted as needs by some respondents.

4.5 TRENDS IN WASTE QUANTITY AND QUALITY

The survey of representative Ontario chemical manufacturing industries revealed that the over-riding factor influencing possible trends in waste quantity and quality was the current state of the economy. As might be expected, production had been reduced at several plants, with attendent decrease in waste quantities generated. An interesting minority opinion was expressed by one manufacturer who reported that his ability to effectively reduce waste generation was impaired by short production runs caused by soft market conditions. Also, several respondents commented that the lack of current budgets for capital expenditures was stalling waste reduction efforts.

In terms of predicting trends in waste generation rates, fifteen waste streams were predicted to decrease and only six predicted to increase. The trend to increased waste quantities was related to optimism for improved market shares. Some of these respondents considered that they had already effected the maximum possible reduction of the waste streams.

Decreases in waste generation were predicted most often on the basis of improved housekeeping practices. Training personnel, closer attention to product spills, and tighter control of process efficiency were initiatives reported for implementation soon. Some respondents reported that they intended to install improved production processes which they expect to yield lower amounts of waste. These included continuous over batch operations, internal process recycling and more efficient distillation equipment. Further reductions were predicted by others when they install separation equipment (i.e. sedimentation and filtration) to increase the concentration and hence, reduce the volume, of waste streams.

Reuse initiatives planned by respondents were limited to industries expecting to use organic wastes as fuels. Recycle was predicted for both spilled and recovered product, which was previously wasted, and for some solvents which were reported as recycled off-site currently.

In summary, the quantity of waste currently leaving industries is expected to be reduced where feasible, dependent upon disposal costs (which were expected to rise) and the cost of waste reduction. This reduction in waste volume is likely to change the types of wastes generated. For example, aqueous wastes may be transformed into solids or sludges by dewatering, and some sludges resulting from the redistillation of spent solvents may shift from solvent recyclers to major solvent using industries, i.e. larger paint and ink compounders.

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5.0 FABRICATED METAL PARTS INDUSTRY (SIC 34)

5.1 OVERVIEW OF THE FABRICATED METAL PARTS INDUSTRY

Metal fabrication plants involve a broad spectrum of processes, products and materials. The scope of metal fabrication encompasses ferrous and non-ferrous metals undergoing a wide variety of operations and treatments affecting the basic size, shape and configuration of the material as well as surface preparation and finish to best suit the product or assembly. Metal fabrication embraces any metalwork which concerns itself with the following functions(1):

- Metal removal, such as machining plants,
- Metal forming, such as stamping plants,
- Metal joining, such as welding, brazing and soldering,
- Metal finishing, such as solvent degreasing, priming, electroplating and painting.

Table 5-1 contains a breakdown of the metal fabrication industry by Standard Industrial Classification (SIC) and gives information on the total number of companies in Ontario as well as the total number of employees.

The fabricated metal parts (SIC 34) and the primary metal (SIC 33) industries are basic to almost all other manufacturing industries. "The most important end uses of the products from these industries are automobiles, machinery, appliances, electrical equipment, structures, furniture, and containers"(2).

Electroplating and allied processes aside, wastewaters originating in metal fabricating plants are usually similar regardless of whether they originate from small shops or large production facilities. For the most part, waste waters from such plants contain small amounts of metal particles, free and soluble oils and various cleaning compounds used in cleaning either the product or the shop itself.

The major sources of water pollution from the electroplating industry are:(1)

- Cleaning, which is the removal of surface oils, greases, buffing compounds, etc.
- Removal of oxides, rust, scale, etc.
- Electrochemical or chemical processing to provide the basic metal with a surface coating consisting of a plated metal or a chemically deposited, so-called conversion coating, such as phosphate, oxide film, as in blackening, etc.

"Most of the electrochemical process solutions in use, such as electroplating and anodic treatment processes, can be maintained in working order by periodic or continuous filtration, purification, or additions of various chemicals for replenishment, but many process solutions employed in finishing either cannot be completely purified or the purification is uneconomical, in which case the process solution itself will reach a point where dumping is necessary and a new process solution has to be made up. Under this category would come, as an example, chromium plating solutions contaminated by iron, copper, nickel, etc. Anodizing solutions for aluminum processing, some of the cyanide type plating solutions, and chromating or phosphating type conversion coating processes"(1). These process solutions may be considered primary subjects for waste treatment. However, in many cases, they may also be considered suitable for chemical recovery.

The following sections examine more closely the processes, wastes and recovery techniques involved in the fabricated metal parts industry.

TABLE 5-1

THE ONTARIO FABRICATED METAL PARTS INDUSTRY(3)

SIC. No.	Description	Total No. of Companies	Total No. of Employees
3411	Metal cans	20	3,881
3412	Metal barrels, drums	10	1,096
3421	Cutlery	5	478
3423	Hand and edge tools (excluding machine tools and hand saws)	32	1,478
3425	Hand saws and saw blades	8	672
3429	Hardware	92	3,997
3431	Enamelled iron	16	597
3432	Plumbing fixtures, fittings and brass goods	28	2,269
3433	Heat equipment excluding electric and air furnace	73	2,426
3441	Fabricated structural metal	128	6,103
3442	Metal doors, frames	178	4,736
3443	Fabricated plate work boilers	208	8,377
3444	Sheet metal work	331	8,845
3446	Architectural metal work	184	2,165
3448	Prefabricated metal buildings and components	31	1,324
3449	Miscellaneous metal work	28	788
3451	Screw machine products	53	1,287
3452	Bolts, nuts, screws	43	4,021
3462	Iron and steel forgings	15	1,614
3663	Non-ferrous forgings	3	287
3465	Automotive stampings	49	5,823
3466	Crowns and closures	5	472
3469	Metal stampings	118	5,313
3471	Electroplating, plating, polishing, anodizing and colouring	124	3,046
3479	Coating and engraving	66	1,583
3482	Small arms ammunition	2	12
3484	Small arms	2	88
3493	Steel springs except wire	20	1,686
3494	Valves and pipe fittings	86	2,765
3495	Wire springs	15	582
3496	Miscellaneous fabricated wire products	82	2,924
3497	Metal foil and leaf	3	42
3498	Fabricated pipe fittings	37	1,604
3499	Fabricated metal products	75	3,598

5.2 MAJOR PROCESSES, WASTE STREAMS AND REDUCTION TECHNIQUES

This section describes the major processes involved in the fabricated metal parts industry sector, the types of wastes emanating from such processes and any applicable waste reduction, recovery and recycle techniques. The process descriptions are divided into three groups: mechanical, chemical and electroplating. Greater emphasis is placed on the description of electroplating processes and wastes as it is the single most important activity within this industry sector with respect to waste generation.

Mechanical Process Descriptions

Mechanical operations performed in the fabricated metal parts industry include:

- Sand Blasting
- Barrel Finishing
- Grinding
- Polishing
- Buffing.

All operations involve the contact of the workpiece with an abrasive material. The purpose may be the removal of burrs, edges, scales or other contaminants from the surface of the metal or to achieve a desired surface finish. A wide variety of abrasive media is used, including aluminum oxide, silicon carbide, steel grit, plastic beads, nut shells, glass, granite, etc. The waste from these operations may include some or all of the following:

- The material being removed from the workpiece
- Some metal from the workpiece
- Any coolants or chemical compounds used in the operation
- The abrasive material (if not recycled).

1. Sand Blasting - Sand blasting or abrasive cleaning involves the forceful direction of abrasive particles against the surface of a metal part to remove contaminants. The quantity of material removed by this method depends on the type and quantity of abrasive material used, and the pressure with which it is applied. Many of the abrasives can be recycled, and so, dirt, soil and scale need be the only waste products from dry blasting operation.(4)

2. Barrel Finishing - Barrel finishing (mass finishing) involves the tumbling of several parts at the one time to remove burrs, edges and scales. Chemical compounds such as sodium cyanide, sodium phosphate, soaps, wetting agents or proprietary compounds are often used in conjunction with the media and so find their way into the waste stream.

3. Grinding, Polishing and Buffing - These operations are performed on the workpiece using wheels and abrasives. Grinding may be performed to achieve a desired surface finish or close dimensional tolerance.(4) It removes substantial amounts of material from the workpiece while polishing removes some material but leaves fine lines and finally buffing smooths the work and leaves a lustre.(4,5,6)

   Grinding is often associated with hard chromium plating where a thick plate is applied and ground down to final dimensions. Grinding may be performed with or without lubricants or coolants.

   "Polishing is performed by wheels made of muslin, canvas, felt or leather".(6) Abrasives used in this operation include natural products such as tripoli as well as synthetic oxide and silicon carbide.

   "In each of these operations, substantial exhaust systems are required as particles of abrasives, metal, cloth and lubricants are carried to cyclones or water scrubbers for removal. In the instance of scrubbers, the resultant slurry must be removed."(6)

Chemical Process Descriptions

1. Cleaning

A number of chemical processes are used prior to some intermediate or final metal finishing operation. The cleaning process involves the removal of soil, grease, oil scale or oxide films from the surface of the metal. The main cleaning processes utilized in this industry may be classified in the following manner:

- Degreasing
- Alkaline Cleaning
- Acid Cleaning
- Detergent Cleaning.

The waste from these processes includes the material being removed from the workpiece as well as the medium being used to clean it.

- Degreasing - Two methods of degreasing are practiced in the fabricated metals industry:

    - Vapour degreasing - when the workpiece is suspended in the vapour phase of a boiling solvent.

    - Dip cleaning - when the workpiece is immersed in a tank of cold solvent.

  Vapour degreasing is an excellent cleaning process because the vapour has not been contaminated from previous cycles. It is often used to remove lubricants high in nonsaponifiable oils or sulphurized or chlorinated components. Solvents used include trichloroethylene, perchloroethylene and trichlorotrifluoroethylene(4).

Dip cleaning or emulsion cleaning involves the use of emulsifiable solvents, emulsion cleaners and diphase cleaners to remove gross soil from the work. "These contain petroleum or organic solvents"(6).

- Alkaline Cleaning - "Alkaline cleaning involves the application of aqueous solutions of sodium compounds such as carbonate, phosphate, silicate or hydroxide with or without the addition of surfactants or chelating agents"(4). Most alkaline cleaning solutions are proprietary(4). While the pieces may be sprayed or soaked, electrolytic cleaning produces the cleanest surface available by conventional methods of alkaline cleaning(5).

- Acid Cleaning - Acid solutions are often used to remove oil and metal oxides and to produce light phosphate coatings. Acids used include nitric, hydrochloric, hydrofluoric, sulphuric, chromic, acetic and phosphoric acids. "They are used with water miscible solvents and organic wetting and emulsifying agents"(6).

- Detergent Cleaning - "Detergents which contain buffering salts, sequestering agents, dispersants, inhibitors, wetting agents and/or soaps are another category of cleaners. Detergents wet, emulsify, dispose and solubilize the soil"(6).

2. Coating

Coatings are applied to either previously deposited metal or basic materials for corrosion protection, lubricity, surface preparation (e.g. for painting) or surface finish. Chromating, phosphating, passivating metal colouring, non-metallic coating and immersion plating are six coating processes used in the industry(5).

Chromating (Conversion Coating) - The process of chromating involves the immersion of the metal in an aqueous solution of chromic acid or chromium salts so that some of the metal and a film containing complex chromium compounds is formed on the surface of the metal. Most solutions are made by using proprietary components. "Published data indicate that chromating solutions contain 2 to 35 mg/L hexavalent chromium supplied in the form of chromic acid or salts such as potassium chromate or dichromate. The solutions also contain other anions such as sulphate, nitrate, chloride or fluoride"(4).

Phosphating - "Phosphating conversion coatings are formed by the immersion of iron, steel, or zinc plated steel in a dilute solution of phosphoric acid plus other reagents. The basic chemicals used are zinc and iron phospates with phosphoric acid"(5). "Manganese phosphates are occasionally used for extreme conditions. Concentrations vary from 5-10% by volume"(6). "Small parts are coated in barrels immersed in the phosphating solution. Large parts, such as steel sheet and strip are spray coated or continuously passed through a phosphating solution. Supplemental oil or wax coatings are usually applied after phosphating unless the part is to be painted"(5).

This process generates a sludge of reaction products which accumulates in the bottom of the process tanks or in the sumps of the spray systems.

Passivating - Passivating treatments involve the immersion of stainless steel workpieces in an aqueous solution containing 5 to 25% by volume of nitric acid. The passivating treatment dissolves foreign substances such as lead, copper, cadmium or imbedded iron particles remaining from prior operations.(4)

Metal Colouring - Metal colouring by chemical conversion methods is used to produce a decorative finish (i.e., antiquing) on copper, steel, zinc and cadmium. Application of the colour to the cleaned basis metal involves a brief immersion in a dilute aqueous solution(5). "Most antiquing effects are obtained from alkaline sulphide solutions and thiosulphates. One formula for gun-barrel blueing contains copper sulphate, mercuric chloride, ferric chloride, nitric acid and denatured alcohol"(6).

Immersion Plating - "Immersion plating is a chemical plating process in which a thin metal deposit is obtained by chemical displacement of the basis metal"(5). Common processes include(5):

- tin on brass, copper, steel or aluminum
- copper on steel
- gold on copper or brass
- nickel on steel
- zinc on aluminum.

Non-Metallic Coatings - Painting is the most widely used metal finishing process and its application is well understood.(6) Paintmakers have, in recent times, been reducing the amount of solvents in paint. "Conventional paints are composed of three basic components: a film form binder consisting of resins or drying oils: a volatile organic solvent or water to maintain fluididity, and a pigment system containing colouring and extenders. Conventional solvent-borne paints contain 60 to 80% volatile organic solvents".(7) However, the following coatings are increasingly used nowadays:

- Water-borne coatings - with up to 80% of the volatiles being water.

- High solids coatings.

- Two component catalyzed coatings.

- Radiation-curable coatings.

- Powder coatings.

Paint is applied in a number of different ways:

- Spray painting
- Roll coating
- Electrocoating
- Sputtercoating.

Recycling overspray is becoming fairly common among large users of paint. One serious problem with recycling overspray is that the paint dries and becomes unworkable as a new paint. "Recycling is more efficient if the drying or curing factor can be minimized".(7)

For further information on paints and painting techniques see reference 7.

3. Acid Treatment

The three main acid treatment processes employed in the industry are:

- acid cleaning (see p. 5-7)
- pickling - which is the removal of fairly thick oxide films and usually involves removal of some metal from the workpiece
- bright dipping - which involves the removal of relatively thin oxide films without any significant removal of metal.

"Pickling is usually performed as a preparatory step before finishing, while bright dipping is usually an intermediate or final step in a finishing process sequence".(4) Typical acids used in both pickling and bright dipping include sulphuric (100 to 150 g/L), hydrochloric (80 to 120 g/L), phosphoric and nitric(4). Sometimes organic acids such as acetic acid are used in bright dipping. In pickling, inhibitors are frequently used to minimize attack on the metal. Concentrations vary from 5% to 50% by volume. Scale loosening may be performed using a solution of potassium permanganate and caustic soda or soda ash followed by pickling(6).

4. Electroless Plating

"Electroless plating is a chemical reduction process which depends upon the catalytic reduction of a metallic ion in an aqueous solution containing a reducing agent and the subsequent disposition of metal without the use of external electrical energy".(5) The basic contents of an electroless plating solution are:(5)

- A source of metal, usually a salt
- A reducer to reduce the metal to its base state
- A chelating agent to hold the metal in solution
- Various buffers.

The process can be performed on metal or plastic surfaces. All plastics require catalytic preparation prior to plating(5). Electroless plating is often followed by electroplating.

The simplest form of electroless plating is a coating process called immersion plating (See p. 5-9).

5. Chemical Milling and Etching(5)

"Chemical milling and etching processes are used to produce specific design configurations and tolerances on metal parts by controlled dissolution with chemical reagents and etchants. The amount of metal removed or the depth of removal is controlled by the immersion time in the milling solutions. Typical solutions for chemical milling include ferric chloride, nitric acid, ammonium persulphate, chromic acid, cupric chloride, hydrochloric acid and combinations of these reagents".(5)

Chemical etching is the same process as chemical milling except that relatively small amounts of metal are removed.

6. Electroplating Process Descriptions

- **Cadmium Plating**

  For cadmium plating, cyanide baths are by far the most popular because they cover the workpiece completely and give a dense fine grained deposit which can be made very lustrous by the use of stable brighteners(5).

Contents may vary as follows(8):

- metal cadmium	15 to 20 g/L
- sodium cyanide	90 to 120 g/L
- soda	30 to 150 g/L

- **Chromium Plating**

"Unlike copper and nickel plating processes which utilize soluble copper or nickel anodes to replenish the metal deposited on the workpieces, chromium electroplating processes always use insoluble lead alloy anodes. Thus, some portion of the chromic acid added regularly for maintenance is consumed by reduction to chromium metal at cathode surfaces".(5) There are two types of chromium plating practised - decorative and hard, the difference between the two being that a much thicker coat is applied with hard chromium plating.

Chromium deposits are mainly obtained from solutions composed of hexavalent chromium, such as chromic acid. Catalytic agents are required to achieve deposits in a hexavalent chromium medium. Catalysts used include sulphate ions, fluosilicate, fluoborate and fluoride. A standard bath composition may be as follows(8):

- Chromic Acid:	250 to 300 g/L
- Catalyst:	1%

- **Nickel Plating**

Nickel may be electroplated from several baths, i.e., Watts (sulphate-chloride-boric acid), sulphamate, all chloride and fluoborate baths. "Each type of solution is prepared with the corresponding nickel salt, a buffer such as boric acid, and a small concentration of a wetting agent. A small amount of organic chemical may be added as a brightener".(5)

The most widely used nickel plating baths is the Watts type, containing simple nickel salts. The standard composition is as follows(8):

- nickel sulphate:	300 g/L
- nickel chloride:	60 g/L
- boric acid:	50 g/L
- additives	

- Copper Plating

Copper is plated from a number of baths, among them alkaline cyanide, acid sulphate, pyrophosphate and fluoborate which are prepared with the corresponding copper salt. An organic chemical may be included for refining or brightening the plate.(5)

Typical bath compositions are as follows(8):

Cyanided copper plating bath

- copper cyanide	25 g/L
- sodium cyanide	35 G/L
- sodium carbonate:	30 g/L
- rochelle salt:	45 g/L
- soda for pH:	12 to 12.5
- brightener:	) Depends on supplier
- penetrant:	)

Acid copper plating bath

- hydrated copper sulphate:	200 to 250 g/L
- sulphuric acid:	50 to 70 g/L
- sodium chloride:	50 to 100 g/L
- additional agent:	Depends on supplier

- **Zinc Plating**

"Zinc is widely used in industry for the protection of steel from corrosion".(8) During the past five years, the use of non-cyanide alkaline solutions has increased to avoid dealing with the cyanide waste problem(8).

Typical bath compositions for zinc plating are(8):

Cyanide zinc plating bath:

- zinc metal	38 g/L
- sodium cyanide:	100 g/L
- sodium hydroxide	100 g/L
- sodium carbonate:	60 g/L
- sodium sulphide:	1 to 2 g/L
- brightener:	Depends on supplier

Acid zinc bath:

There are two kinds of acid zinc baths:

-Ammonium chloride bath
-Potassium chloride bath

The potassium chloride bath was developed to prevent the use and waste of ammonia.(8)

- zinc metal	20 to 30 g/L
- chloride (as NH_4Cl or KCl):	130 to 150 g/L
- boric acid:	15 to 150 g/L
- brighteners:	Depends on supplier
- pH:	5 to 6

Iron Plating

Iron electroplating solutions are comparatively stable and simple to operate. However, special non-corrosive equipment is needed to heat and agitate the plating bath. Care must also be taken that the plating bath does not oxidize(5). "Fluoborate ions have to be treated where such a bath is used. Small amounts of ferric ion in the sulphate and chloride baths precipitate as hydroxide or oxides and are removed by filtration".(4)

Typical bath compositions are as follows:(4)

Sulphate/chloride bath

- ammonium chloride:	20 g/L
- ferrous sulphate:	250 g/L
- ferrous chloride:	30 g/L

Fluoborate bath:

- ferric fluoborate:	225 g/L
- sodium chloride:	10 g/L
- boric acid:	22.5 g/L

Tin Plating

Tin is deposited from both acid and alkaline solutions. "The common baths of alkaline stannate and acid fluoborate produce a matte finish while the acid sulphate process can result in either type of deposit".(5)

The bath compositions for tin plating are as follows:

Alkaline stannate bath:(4)

- potassium stannate:	100 to 420 g/L
- potassium hydroxide:	15 to 22 g/L
or	
- sodium stannate:	100 g/L
- sodium hydroxide	10 g/L

Sulphate bath(4):

- stannous sulphate:	53 g/L
- sulphuric acid:	98 g/L
- cresol sulphonic acid:	98 g/L
- ß-naphthol	1 g/L
- gelatin:	2 g/L

For fluoborate bath composition see Reference 4.

- **Lead Plating**

Fluosilicate and fluoborate baths are most widely used in lead electroplating. "The fluoborate bath is more expensive, but it gives finer grained, denser deposits, adheres better to steel and does not decompose as readily".(5)

- **Aluminum Plating**

The only commercial application for aluminum plating has been from a hydride bath containing diethyl ether, aluminum chloride and lithium aluminum hydride(5).

- **Gold Plating**

Gold electroplating may be applied to provide any of the following:

- decorative finish
- corrosion protection
- electrical contact surface
- bonding surface
- electroformed conductors.

Plating baths have been developed for each of these applications. Four types of gold baths are used. "Three of these are cyanide baths - unbuffered alkaline with a pH range of 8.5 to 13, acid buffered with a pH range of 3 to 6, and a neutral buffer with a pH range of 6 to 8.5. The fourth is non cyanide".(5)

A cyanide gold plating bath is composed as follows:(4)

gold:	1 to 8 g/L
free potassium cyanide:	0.1 to 30 g/L
potassium phosphate:	15 to 30 g/L
potassium carbonate:	0 to 30 g/L

- Silver Plating

Silver is normally electroplated in two types of baths: a conventional low metal bath or a high speed bath with a much higher silver content.

"The silver in plating baths is present as a cyanide complex, together with free cyanide and carbonate. Silver concentrations vary from 25 to 75 g/L. Additives are used for grain refinement and brightening".(4)

- Platinum Plating

Rhodium is the only metal in the platinum group electroplated to any great extent.

"Rhodium electroplating baths are supplied as phosphate or sulphate concentrates. The only additions made to the diluted concentrates are phosphoric and/or sulphuric acids at concentrations of 25 to 75g mL per litre of plating bath. A rhodium concentration of 2.0 g/L is used for decorative coatings".(5)

7. Anodizing

"Anodizing is an electrolytic oxidation process by which the surface of the metal is converted to an insoluble oxide having desirable chemical and physical properties".(4) Aluminum is the metal mostly treated, although some magnesium, zinc and titanium are also treated. Aluminum is anodized in 12 to 15% sulphuric acid to produce an oxide coating for corrosion protection. "Aluminum may also be anodized using chromic acid, oxalic acid or boric acid"(4).

Electroplating Wastes

- **Water Pollution Control Sludges**

The source of these sludges is the process solution dragged out by the workpiece as it is moved from tank to tank in any plating operation. The concentrated process solutions carried out as drag out are rinsed in continuously flowing water at a rate which ranges from 4 to 40 litres per minute. These rinse waters contain alkalis, acids with dissolved metals, and possibly cyanides. The metal being plated onto the workpiece appears as a dissolved salt in the rinse water following metal deposition. Drag out from any post-plating step will contain metals and chemicals also. All rinse waters from the plant should be collected in three separate streams:(4)

- Cyanide-bearing waste streams
- Chromium-bearing waste streams
- Acid, alkali and metal salt solution (exl. above) waste streams.

These streams undergo conventional waste treatment as follows(9):

- Oxidation of the cyanide-bearing waste streams to oxidize the toxic cyanides to harmless carbon and nitrogen compounds.
- Reduction of segregated chromium waste streams to reduce the chromium from its hexavalent form to the trivalent state.

- Neutralization of the combined metal bearing wastewaters, acid/alkali wastewaters, strong chemical dumps and effluent from the cyanide and chromium treatment systems to adjust the pH to within acceptable discharge limits and precipitate the dissolved heavy metals as hydroxides.

- Clarification, where flocculating/coagulating chemicals are added to promote the initial settling of the precipitated metal hydroxides.

- Gravity thickening over extended time to increase solids content of sludge before disposal.

Because plating solutions contain valuable metals in concentrations as high as 200 g/L, as well as chemical salts and additives, solutions are maintained by purification and filtering and are rarely disposed of. However, pre and post-plating solutions, such as alkaline soak and electrolytic cleaners, acid and cyanide dips, pickles, descaling baths, chemical and electrochemical polishing baths, oxidizing, phosphating, colouring and conversion coating solutions are often dumped. The choice of treatment chemical for metal hydroxide precipitation is between slurried lime $Ca(OH_2)$, or caustic soda NaOH, purchased dry or in liquid form.

"Precipitation with lime is generally preferred since it produces a sludge wherein the gelatinous hydroxide colloids are less difficult to settle and easier to separate than with caustic"(4). Coagulants are often used to aid sedimentation and separation.

The quantity of sludge produced in an electroplating and metal finishing plant is not uniform for any given process because the drag out and spills vary from plant to plant (see Reference 4 for more detail).

Filtration Wastes(4)

It is necessary to continually purify the solutions in electroplating baths to remove suspended solids and organic contaminants as well as dissolved metals foreign to the bath. "As a general routine, copper, nickel, zinc, tin, silver and gold, or cadmium baths are continuously filtered at a rate of 0.25 to 6 times the bath volume per hour".(4) Filter aid is often used. Heavily contaminated baths are usually batch treated in a separate purification tank. "Only the filter cake is disposed of when precoat filter membranes are used. When filter discs made of paper or yarn-wound cartridges are used, they are disposed of along with the filter cakes each time a filter is cleaned".(4) In the case of the former, the waste is usually discarded by backwashing the filter to a water pollution control facility, where available, or to the sewer. With discs or yarn-wound cartridges, these would be discarded with the general refuse.

Anode Wastes(4)

In processes such as chromium plating, precious metal plating, anodizing and electropolishing where insoluble anodes are used, a small loss of anode material is encountered during inactive periods. This material settles as a sludge on the tank bottom and can be removed chemically.

Bags are used for most soluble anodes to collect insoluble anode materials during the electrochemical dissolution. The bags are fitted loosely around the anodes.

Plating Racks(4)

The coating material (e.g. rubber, vinyl, neoprene, etc.) used on racks have a limited life because of the corrosive nature of the plating solutions. It is usually softened with an organic solvent mechanically stripped and landfilled.

Tank Linings(4)

"Plating tanks are generally protected from corrosion by various linings. The linings are made of rubbers and plastics, thermosetting resins and metallics, which, in most cases, is lead".(4) These linings may have to be replaced occasionally due to damage from tears or extreme heat.

Oil Emulsions(4)

"Cutting oils and soluble oil coolants used in mechanical operations in a metal finishing shop become part of the shop waste".(4) These wastes are handled in the waste treatment system by oil skimmers or are precipitated with ferrous or aluminum salts.

Other Wastes

Included are paint and paint solvents, stopoffs, and hydraulic oils (For more details see reference 4).

Waste Reduction, Reuse and Recycle Technologies

Evaporation

Evaporation involves the distilling of the wastewater until there is a sufficiently high concentration of plating chemicals to allow for reuse in the plating operation. It is a very common method for plating chemical recovery and has been used for chromic acid, bright nickel plating solutions, copper sulphate, silver cyanide, copper cyanide and zinc cyanide recovery. Most success has been achieved with chromic acid, nickel and simple copper salts, where the original process solution can be recovered in virtually its original form. It is less suited to solutions containing volatile species such as cyanide, where foaming may occur.(19) Closed-loop evaporating recovery systems have proven quite successful recently (see reference 10 for more details).

The main disadvantage of this recovery method is the high cost of both capital investment and energy costs.

For further information, see References 10, 11, 12, 13.

Ion Exchange

Ion exchange involves the passing of a chemical solution, i.e., the wastewater, through a bed of resin, which selectively removes either the positively charged cations (e.g. Cu^{+2}, Fe^{+2}) or the negatively charged anions (e.g. CrO_4^{-2}, CN^-) from the solution. The removal is accomplished by the exchange of an ion from the surface of a resin particle for a similarly charged ion in the solution(14). This process is reversed during the regeneration cycle where the removed ions are chemically released from the surface by a regenerant solution. The recovered chemicals are not in their original form but are a derivative salt. The regenerant effluent, as well as containing the recovered chemical, contains any excess regenerant agent. Ion exchange has been demonstrated commercially for recovery of plating chemicals from acid copper, acid zinc, nickel, tin, cobalt and chromium plating baths. The process can also be used to recover spent acid solutions and to purify plating solutions for longer service life(15).

This recovery method is especially suited for the separation of dilute concentrations of ionic compounds from water solutions. However, it does not run well on cyanide rinse waters and resins are poisoned at concentrations above 200 mg/L.

For further information see References 16, 17, 18.

Reverse Osmosis

Reverse osmosis accomplishes much the same result as evaporation in that it separates an effluent into a concentrated solution of the dragged-out chemicals and nearly pure water. "The process reverses the normal osmotic pressures by applying a considerably greater pressure (400 to 800 psig) to the concentrated solution, thus forcing the water into the diluted solution, leaving behind most of the dissolved salts"(6). Application of this method is limited to those baths with high drag-out rates(4). The main application is the concentration of rinse waters from acid nickel plating baths,(14, 19, 20) although indications are that this may be extended to nickel sulphamate, zinc chloride, copper cyanide, zinc cyanide and cadmium cyanide plating baths(19). However, the cost of membranes may make cyanide waste treatment unattractive. Reverse osmosis cannot achieve the same degree of concentration as some other methods. Therefore, supplemental evaporation is sometimes required. An advantage of this method is that energy consumption is comparatively low. However, high capital costs coupled with membrane replacement because of fouling and/or deterioration are drawbacks of this method.

Electrodialysis

This process is carried out in electrochemical cells using ion permeable membranes to form anode, cathode and central compartments. Contaminated rinse waters in the central compartment are purified as the metal ions are drawn through the membrane into the cathode compartment and the anions into the anode compartment(21). Current electrodialysis applications include the recovery of drag-out from rinses after nickel, acid zinc, zinc cyanide, and chromium plating processes. Electrodialysis can be used to concentrate chromic acid existing in a static rinse up to concentrations of 200 to 300 mg/L. It can also be applied for continuous regeneration of hydrochloric acid pickling baths where iron is separated as a metal and hydrochloric acid is restored.

Electrodialysis membranes are durable to most chemical environments. However, closed-loop systems are susceptable to a build-up of impurities with electrodialysis and considerable energy is consumed by this method(21).

Electrolytic Recovery Techniques

"Electrolysis is commonly used to recover a wide variety of metals such as copper, zinc, tin, silver and gold dragged out from process solutions, whether pickling or plating. An electrolytic recovery cell is usually connected in a recirculating closed-loop with a drag-out tank following the plating stage so that a low metal concentration is continually maintained to reduce drag-out losses to a minimum. The economics of electrolytic recovery vary from metal to metal. In general, relatively small losses of silver and gold are very worthwhile recovering due to their high value, whereas large quantities of copper must be recovered to justify the relatively high capital cost".(13) The recovered metal is as pure as the process solution from which it was lost(13).

A system using basic electrochemical technology was developed by HSA Reactors Ltd. of Rexdale, Ontario. In this system, the rinse water is circulated through a reactor module (or modules) which contains a cathode made of specially woven fibre that gives the reactor more than 2 million square feet of cathode surface per module, and results in the dragged-out metal being electrochemically deposited on the cathode(s). "The metal is stripped from the cathode either chemically or electrochemically, depending on the metal type".(22) This particular recovery system has been applied to copper, zinc and cadmium plating lines. An economic advantage of this system is its low energy consumption - about 2 kW DC per reactor module(22).

Donnan Dialysis(14)

"Donnan dialysis is a membrane separation process similar to reverse osmosis or electrodialysis".(14) The driving force used in Donnan dialysis is a result of concentration differences across the membrane as opposed to pressure or electrical potential difference. Development of this method has been impeded by the lack of a stable ion exchange membrane. However, a new resin developed by DuPont may provide a cation exchange membrane of exceptional chemical resistance and good mechanical properties.

Starch Xanthate Precipitation(14)

Insoluble starch xanthate (ISX) is prepared by reacting highly cross-linked starch with caustic, carbon disulphide and magnesium sulphate. The ISX acts as an ion-exchange material or resin, removing the heavy metal ions from the wastewater and replacing them with sodium and magnesium. The metals are recoverable from the ISX sludge, but, currently, only gold is recovered. A disadvantage of this process is that it generates a significant amount of sludge (10 kgs of ISX are required to remove 1 kg of copper).

Acid Purification

A process developed by Eco-Tec Ltd. of Pickering, Ontario, enables the removal of dissolved metallic salts from mineral acids. The key to the Acid Purification Unit (APU) is a bed of special sorption resin, which has the ability to 'sorb' strong mineral acids, e.g., sulphuric, hydrochloric, nitric, etc., yet exclude metal salts such as iron, aluminum, copper, sodium, etc. Only water is needed to desorb the acid from the resin. "In metal finishing applications, the APU is typically operated directly on the process bath, continuously removing dissolved metallic impurities and recycling purified acid."(15) For ion exchange units, this process may be used to purify the spent acid regenerant. The process has application for anodizing, pickling, etching, brightening, electropolishing and bright dipping processes.

For further information see reference 15.

Solvent Recycling(7)

"Most solvent recyclers use the same basic process to reclaim solvents. The stages in the process include storage and handling, initial treatment, distillation, dewatering, waste disposal, solvent handling, packaging and final storage".(7) The most important stage in the process is distillation, the purpose of which is to remove dissolved impurities in the solvent and to separate solvent mixtures. "Where distillation involves heating and condensing the solvent, hydrocarbon losses from the exhaust stack may be significant".(7) However, solvent vapours vented during distillation can be controlled by scrubbers and condensers. 25% or less of the dirty solvent remains as a waste residue at the end of recovery process. This residue may be burned to provide heat for the distillation process.

If a business generates waste solvents in the vapour form, these wastes must be treated on the premises, or at least condensed into a liquid form. Two methods for capturing such solvents are carbon adsorption and liquid nitrogen based solvent recovery.

Minimizing solvent losses during degreasing operations can be achieved by the following techniques:

- Keeping covers on tanks.

- Increasing the height of the degreaser freeboard, i.e., the height of the tank above the vapour level.

- Installing a second set of condensing coils, also known as chillers in the degreaser. This has the effect of creating a cold blanket above the vapour zone and prevents the escape of vapours.

- Distilling recovered vapours.

5.3 APPROACHES TO WASTE REDUCTION IN ONTARIO AND CURRENT DISPOSAL PRACTICES

Waste disposal, recycle, reduction and reuse, as practiced by a cross section of the Ontario fabricated metal parts industry is discussed in the following sections.

Table 5-2 summarizes the waste streams reported from the 68 plants interviewed. The results suggest that the majority of firms in this sector have scrap metal waste which almost all recycle, and would not require consideration by OWMC. Nine of the companies interviewed reported that they had no waste which they felt would require special treatment.

Table 5-3 identifies the fates of the various waste streams as reported. Some difficulty was experienced here in designating a 'fate' to some acid treatment and electroplating waste streams because some plants consider their waste process generated, while others count it as coming from a waste treatment facility. A number of plants gave their wastes with the water fraction included, while others identified sludge quantity figures.

Table 5-2 indicates that a wide range of firms generate spent solvent waste. The fate of these waste streams (Table 5-3) is divided fairly evenly between disposal and recycling, although, when actual volumes are taken into account, only a 20% recycling rate is estimated.

However, a 60% recycling rate was reported on a generated volume basis for waste oils. In addition, it is probable that some of the waste oil taken by waste disposers is recycled.

The majority of paint waste, some of it in liquid form but mostly in a solid or sludge state, is disposed of off-site. None of it is recycled while three streams are reused. Those dumping it with their ordinary factory refuse are small generators and much of it would be used paint cans, rags, and the like.

TABLE 5-2

SUMMARY OF WASTE STREAMS FROM THE PLANTS INTERVIEWED - FABRICATED METAL PARTS INDUSTRY

SIC Group	No. of Interviews	Waste Type Solvents	Oils*	Paints	Acids	Electro-plating	None
3411 Metal Cans	3	1	2	1	1	-	-
3412 Barrels & Drums	1	1	-	-	-	-	-
3421 Cutlery	1	-	-	-	-	1	-
3423 Hand & Edge Tools	3	-	-	-	-	1	-
3425 Hand Saws & Blades	1	-	1	-	-	-	-
3429 Hardware	5	2	2	-	-	1	1
3432 Plumbing	2	1	-	-	-	-	1
3433 Heating Equipment	2	-	1	1	-	-	1
3441 Fabr. Structural Metal	5	-	2	4	-	-	1
3442 Metal Doors & Frames	3	2	3	1	1	-	-
3443 Fabr. Plate Work & Boilers	3	-	3	1	-	-	-
3444 Sheet Metal	3	-	1	-	-	-	2
3445 Architechtural	1	-	1	-	-	-	
3448 Prefab. Metal Buildings	3	-	1	1	-	-	1
3451 Screw Machine Products	3	1	1	-	-	-	-
3452 Bolts, Nuts, Screws	3	1	3	-	1	2	-
3462 Iron & Steel Forgings	3	1	2	-	-	-	-
3463 Non-ferrous Forgings	1	-	1	-	1	-	-
3465 Automotive Stampings	1	-	-	-	-	-	-
3466 Crowns & Closures	1	1	1	-	-	-	-
3469 Metal Stampings	4	2	-	2	-	3	1
3471 Electroplating	1	-	-	-	-	1	-
3479 Coating & Engraving	1	1	-	1	-	1	-
3482 Small Arms Ammunition	1	-	-	-	-	-	-
3493 Small Arms	3	-	-	-	-	-	2
3494 Valves & Pipe Fittings	3	1	1	-	-	-	-
3495 Wire Springs	1	-	-	-	-	-	-
3496 Misc. Fabr. Wire Prod.	3	1	2	-	1	-	-
3499 Fabr. Metal Prod.	3	-	1	2	1	1	-
Total	68	16	30	16	6	11	9

* Aggregate of water soluble oils, water insoluble oils, and mixed oils and coolants.

TABLE 5-3

SUMMARY OF FATE OF WASTE STREAMS - FABRICATED METAL PARTS INDUSTRY

Waste Type	Fate (No. of Waste Streams) Industrial Waste Disposal	Recycle	Reuse	Refuse	Sewer	Watercourse	Stored/ Disposed on Site
Solvents	7	7	1	-	-	-	1
Water Soluble Oils	7	8	1	-	1	-	2
Water Insoluble Oils	3	7	-	-	-	-	-
Mixed Oils and Coolants	4	3	1	-	-	-	-
Paints	11	-	3	2	-	-	-
Acid Treatment	3	2	-	-	1 (water)	2 (water)	2 (sludge)
Electroplating	5	-	1	-	2	1	1

A miscellaneous section is devoted to those wastes which were reported on a one or two-off basis, such as ceramic sludges, plastics, carbon loaded sludges, etc.

It was found that many of the SIC groups in this industry sector are metal cutting and fabrication facilities, which are not large waste generators. Unfortunately, it was these firms which were the most forward with information even if not of great value, and not those involved in electroplating and acid treatment operations, which are the largest generators of liquid industrial waste in this sector. However, it was these firms which showed the greatest interest in what OWMC is doing for industrial waste disposal. Most are concerned about how best to reduce or eliminate their wastes. Many experience pressure being applied by the local municipality to reduce contaminants being sewered.

Spent Solvents

Sixteen of the plants surveyed reponded that a a spent solvent waste stream was generated. Included were both halogenated and non-halogenated solvents. An approximate total annual generation figure of 360 tonnes was calculated. The fate of the sixteen waste streams can be summarized as follows:

No. of Plants	Fate of Spent Solvents
7	Recycled
1	Burned for heat generation
1	Stored on site
7	Industrial waste disposal

The amount of solvents recycled represents about 20% of the total volume generated.

For those recycling, the average volume recycled per plant per annum is approximately 10 tonnes. This represents a recycling rate range of from less than 0.5 tonnes to 27 tonnes per year for these seven operations.

The quantity of solvents disposed of annually by each plant ranges from just over 1 tonne to 235 tonnes.

The positive responses with respect to this waste were received from firms within the following SIC groups with the number of responses in brackets: 3411 (1), 3412 (1), 3429 (2), 3432 (1), 3442 (2), 3451 (1), 3452 (1), 3462 (1), 3466 (1), 3469 (2), 3479 (1), 3494 (1), 3496 (1).

The number of employees per plant surveyed that generate waste solvents ranges from 15 to 430, with nine of the sixteen plants having less than 100 employees.

Of the eight plants that have their spent solvents recycled, only one has a recovery unit of its own, recycling at a rate of 1900 litres/month. This amount represents about two-thirds of the solvents used. They reported that they were considering reducing the amount of solvents being used in the plant, either by changing the raw materials used or altering the process.

One plant has its waste solvents sent to the United States at a rate of 1500 litres/month, where it is burned for heat generation.

For those operations which do not recycle, the main reason is that they believe their waste volumes to be too small to make recycling enconomically viable. Most of them have their spent solvents taken away by industrial waste disposal firms, the final destination was unknown. It is possible that some of this material is sent to a recycler.

One plant reported that it is having difficulty in disposing of its trichloroethylene degreaser sludge, and that, at present, it has 50 drums of it stored on site. They are considering de-oiling this sludge, but still do not consider it economically sound to recover the solvent. They have, however, recently changed to a different degreaser which would generate only 340 litres per year of waste solvent in the future.

Another of the plants questioned has just recently started to use a detergent cleaner instead of trichloroethylene, because of difficulties in sludge disposal.

One of those plants presently disposing of their waste solvents is unable to get their solvents recycled because it is too far from the nearest recycler to make it economical. They, too, have decided to change their cleaning solvent and will use a water based solvent in the future.

One plant which is disposing of 235 tonnes of spent solvents (thinners) per year say that it has tried recycling but that the solvents are too contaminated to make it worthwhile.

Waste Oils

In this section we have divided waste oils into three different categories.

- Water Insoluble Oils
- Water Soluble Oils
- Mixed Oils and Coolants.

The following table contains a summary of all three categories:

Waste Oil Type	Volume (tonnes)	Volume Recycled (tonnes)	% Recycled
Water Soluble	195	39.0	25.0
Water Insoluble	65	58.5	90.0
Mixed	330	247.5	75.0
Total	590	345.0	58.5

As can be seen, it is estimated that nearly 60% of the waste oils generated by those plants surveyed is recycled. In some cases, where the oil is taken away by waste disposal firms, it is possible that these firms then sell it to the recyclers.

Water Soluble Oils

Approximately 195 tonnes of spent water soluble oils (including cutting oils and quenching oils) are generated annually by the 19 plants identified as having this particular waste stream. The following table summarizes the fate of these 19 streams:

No. of Plants	Fate of Waste Oils (in water solution)
8	Recycled
7	Industrial Waste Disposal
2	Evaporation
1	Dust Control
1	Sewer

Nearly 25% of these spent oils generated is recycled. However, 68% of the total waste volume is generated by two plants who consider it uneconomical to recover, due to the high water content of their streams (90% water).

The recycled waste streams vary in volume between less than 500 kg and 20 tonnes a year for the plants involved. The employment figures for these firms range from 20 to 250 people. For those recycling, the largest employer, at 250 people, is the biggest generator at 20 tonnes per year.

The two largest waste soluble oil generators are also the two highest employers and neither of them recycle.

Firms from the following SIC groups responded positively to this part of the survey: 3425 (1), 3429 (1), 3433 (1), 3441 (2), 3442 (1), 3443 (2), 3444 (1), 3446 (1), 3451 (3), 3452 (2), 3462 (2), 3466 (1), 3494 (1).

Of the eight plants which recycle this waste, two have their own recovery units for their cutting oils. One centrifuges out the metal chips and recovers the oil for reuse at a rate of about 680 litres per year. The other has a recovery unit, recycling about 760 litres per month.

A mobile recovery unit operated by a custom recycler, is employed by one firm to recycle over 15,000 litres of quenching oils per year.

As was mentioned previously, the two largest generators do not recycle, both considering it uneconomical because of the high water content of their waste. One company sends nearly 25 tonnes a year to Tricil, while the other sewers over 100 tonnes annually.

Two firms allow the volatile components to evaporate off prior to disposal. They have very small quantities of waste, each no greater than 0.5 tonnes per annum.

One plant which generates 0.07 tonne (70 Kg) per year of water soluble oils spreads it as a dust suppressant on the company car park.

Water Insoluble Oils

Of the 68 plants surveyed, ten gave water insoluble oil (including lubricating, automotive and hydraulic) as one of their waste streams. The total annual generation reported is approximately 65 tonnes. The quantity recycled represents over 90% of the total generation figure. Below, the fate of the ten streams is summarized:

No. of Plants	Fate of Waste Oils (Water Insoluble)
7	Recycled
3	Industrial Waste Disposal

The average volume recycled per plant is approximately 8 tonnes, and the waste oil generation range for these plants is 300 kg to 39 tonnes per annum.

The yearly waste oil volume for those disposing or landfilling is between 0.03 tonne (30 kg) and 5.3 tonnes.

Plants within the following SIC groups reported generating this waste stream: 3411 (1), 3429 (2), 3442 (1), 3443 (1), 3448 (1), 3451 (1), 3452 (1), 3462 (1) and 3496 (1).

None of the plants surveyed has a recovery unit of its own, and all send their spent oils to either private recyclers or back to the supplier/manufacturer. This is understandable, considering the small volumes involved, and most cited economics as the reason for not installing a recovery unit of their own.

Those who are not recycling their spent oils showed little interest in doing so, primarily on account of the small quantities generated. To date, they have experienced no problems in disposing of this waste stream.

None of the plants has any plans to reduce this waste stream by either process, plant or raw material modification.

None of the plants projected any significant change in the quantity of waste produced. However, this view is probably coloured by the present economic climate.

Mixed Oils and Coolants

In this section, we have placed those waste oil streams which are either not collected separately, or which, due to lack of information, we were unable to place with confidence in either of the other two waste oil categories. These waste streams may include any combination of water soluble and insoluble oils and coolants, and even possibly solvents.

Mixed oil streams were reported by eight plants. The total volume generated annually comes to approximately 330 tonnes, of which 75% is recycled. The fate of these waste streams is summarized below:

No. of Plants	Fate of Mixed Waste Oils
3	Recycled
4	Industrial Waste Disposal
1	Dust Control

The largest generator not recycling said he used to keep the various oils separate for recycling, but now does not consider it worth the effort. The three plants recycling use outside contractors, while one plant utilizes about 5 tonnes per year as a dust suppressant in its car park.

Paint Wastes

Sixteen of the plants interviewed identified waste paint/paint sludge as a waste stream. The total annual generation of this waste by these plants is 115 tonnes. The volume generated by each plant ranges from 150 kg to 30 tonnes per annum.

Of these sixteen plants, eleven have their waste paint sludge taken away by industrial waste disposal contractors.

Two small generators throw it in the factory garbage to be disposed of by the municipal refuse collectors.

One plant sends its paint sludge along with its oils to Tricil.

Another gives it back to the paint supplier, who possibly recycles it.

Finally, one generator mixes it with gravel to help make a pavement.

The SIC groups represented by plants generating paint waste were 3411 (1), 3423 (1), 3433 (1), 3441 (4), 3442 (1), 3443 (1), 3446 (1), 3448 (1), 3469 (2), 3479 (1), 3499 (2).

Acid Treatment Wastes

Six of the plants surveyed reported wastes from acid treatment processes, with one of the plants having two acidic waste streams. Four of these processes are pickling operations, one is an anodizing plant and the last an acid stripping operation.

One pickling plant with approximately 190,000 litres of concentrated pickle liquor a year treats it by neutralization and then allows the sludge to dry to a 'wet cake' by evaporation (approximately 25% original volume) and then dumps it on a site near the plant. At present, they have about 100 m^3 of this 'wet cake' on site. They see their annual waste generation volume increasing by 10% per year, and so are considering various reduction opportunities. However, the interviewee suggested that there is a dearth of objective technical advice (non-sales) available on this problem. This particular sludge contains both copper and zinc, each at 15% by volume, which they would like to recover.

A second plant with a flow of 435,000 litres of pickle liquor every 24 hours treats it before discharging the water to the river. The sludge is dumped in a lagoon near the factory.

The only pickling plant to have its spent liquor recycled generates over 800 tonnes of it a year, and has it recycled by Stelco.

The fourth operation with a spent pickle liquor waste stream has 170 litres of sludge removed by an industrial waste disposal company.

A factory involved in the forging of non-ferrous parts uses nitric acid in a metal treatment process. The process generates about 30 litres/min of nitric acid waste solution, of which 19 litres/min is reused and 11 litres/min neutralized and discharged into the sewer. They would like to develop methods to recover more nitric acid for reuse.

An acid stripping operation generates about 4 tonnes of acid waste liquid and sludge yearly, which it disposes of through its normal waste disposal contractor.

Finally, an anodizing operation which generates 87,000 litres of waste sulphuric acid (15%) a year, uses 34,000 litres for neutralization purposes and has the remainder taken away by an industrial waste disposal service. This plant also generates about 38,000 litres of caustic a year. They are presently looking at the possibilities of a caustic recovery system.

The following SIC groups were represented by those plants responding positively to having an acid treatment waste stream: 3411 (1), 3442 (1), 3452 (1), 3463 (1), 3496 (1) and 3499 (1). Manpower ranged from 70 to 250 over the six plants.

Electroplating Wastes

Eleven of the plants interviewed have electroplating operations, plating metals such as zinc, nickel, chromium, cadmium, tin, brass and bronze. One plant, which plates all of the above except tin, discharges rinsewater at a rate of 297,000 litres/24 hours to a river, following cyanide and chromium treatment. Metal recovery techniques are not applied for economic reasons. Three other plants discharge their wastewater to the sewer. Five of the operations involved have their sludges taken away by industrial waste disposal companies, with another sending its to Tricil in Corrunna.

One company is storing its chromium sludge on site until a suitable treatment or disposal method is found. They may have to send it to the United States.

No plant surveyed is operating a metal recovery system at present. One did install a chromic acid recovery system which subsequently failed. This same plant has just recently put an automatic sludge remover into their treatment plant at a cost of $90,000.

Another plant intends installing a chromic acid recovery system in the near future. They are also putting in an iron nickel bath which can operate at lower nickel concentrations. Only one other interviewee showed any interest in considering metal recovery.

Firms interviewed from the following SIC groups had electroplating wastes: 3421 (1), 3423 (1), 3429 (1), 3452 (2), 3469 (3), 3471 (1), 3479 (1), 3499 (1). Manpower ranged from 60 to 250 per plant.

Miscellaneous Wastes

- Detergents - Three plants reported detergent waste streams, the largest of which is 436,000 litres/24 hours. This stream is treated prior to discharge into a river. The other two plants discharge much smaller quantities to the sewer.

- Coatings - Thirty cubic meters of ceramic sludge is generated by one plant per week. It is taken away by industrial waste disposal companies. Two plants which have plastic coating operations recycle the waste material continuously.

Another plant recycles a dry epoxy which is reused.

- Carbon Loaded Sludges - From quenching operations, only one plant reported such a waste, which is small in volume (2.6 tonnes per year) and which is removed by an industrial waste disposal contractor.

- Polishing Dust - Small in quantity (0.5 tonnes per year), this waste is recycled by the one plant reporting it as a waste stream.

- Desmut Solution - One plant generates nearly 25 tonnes of this annually, and has it taken away by a waste disposal company.

- Inhibitors - One plant reports inhibitors used in a deburring operation as a waste stream at about 750 kg per year.

- Iron Perchloride - One and a half tonnes of waste iron perchloride is generated by one factory. They dispose of it off-site.

5.4 POTENTIAL ROLES FOR OWMC TO ENCOURAGE WASTE REDUCTION

As can be seen from the accompanying table, less than 30% of the plants surveyed held strong views, either positive or negative, with respect to the suggested activities of OWMC outlined in the questionnaire.

Suggested Potential Role for OWMC	Response From 68 Interviews Positive	Negative	Neutral
1. Trained personnel to visit your plant and advise on waste reduction	14 (20.6%)	4 (5.9%)	50 (73.5%)
2. Mobile plant for waste reduction which could visit your plant once or twice per year, e.g., neutralization, dewatering, reverse osmosis units	10 (14.7%)	6 (8.8%)	52 (76.5%)
3. Industry specific seminars on waste reduction	12 (17.6%)	4 (5.9%)	52 (76.5%)
4. Operating a waste exchange program for waste reuse	6 (8.8%)	9 (13.3%)	53 (77.9%)
5. Operating recycling plants for waste streams not adequately dealt with by the private sector	18 (26.5%)	2 (2.9%)	48 (70.1%)
6. Arguing for improved tax incentives for waste reduction	15 (22.1%)	4 (5.9%)	49 (72.0%)
7. Arguing for improved legislation to facilitate waste reduction and reuse	12 (17.6%)	5 (7.4%)	51 (75.0%)
8. Conducting or supporting research and development on waste reduction	18 (26.5%)	1 (1.5%)	49 (72.0%)

Strongly held opinions (positive and negative) varied between 22.1% and 29.4% of the total number interviewed, depending on the suggested activity. The result emphasizes the fact that, apart from those plants involved in electroplating and allied processes, the Ontario fabricated metal parts industry is not a major waste generator and, therefore, does not appear to be overly concerned with industrial waste reduction.

Neutral opinions were generally provided by plants which do not have waste problems. It was felt that the mild opinions of such plants should not be allowed to bias the result of the survey. Also, there were some proposed activities about which plants with a waste problem did not have a strong opinion and so these also were counted as neutral responses. Positive and negative opinions were aired by plants which, to varying degrees, do have a waste problem, and reflect their opinions as to whether the particular service or activity proposed would or would not be of benefit to that plant.

Positive views were held most strongly with regard to activities 5 and 8. The decisive result concerning the operation of recycling plants by OWMC is most significant. Many plants find themselves disposing of recyclable material because existing recyclers are not interested in collecting it. This may be due to the low volume or poor quality of the waste or maybe excessive travelling distance to the recycling plant. As a result some plant engineers feel that there is a potential role for OWMC here.

The greatest positive response of the survey was towards the conducting or support of research and development in waste reduction. This industry sector has many small to medium size operations which cannot afford to invest individually in research and development to come up with better solutions to their waste problems.

Strong positive views were also voiced in support of activities 1, 3, 6 and 7. With respect to Activity 1, one plant engineer with a definite waste problem feels that there is a lack of objective technical advice available to the manufacturer. He believes many plant engineers and managers succumb to good salesmanship and end up with poor waste treatment plants. Other plant representatives expressed the view that, unless the trained personnel were extremely specialized, they would be of little value to them. It was also found that plants belonging to reasonably large corporations often have available to them corporate environmental control teams which have expertise in their plants' processes and waste streams, and so would have little use for a similar OWMC service.

With respect to industry specific seminars, most strongly held opinions were in favour of them. However, a number of interviewees felt that many seminars are too broad-based and so provide little aid in solving the specific problems of their plants, which are often not typical of the industry sector in general.

Although most of these interviewed were in favour of arguing for improved tax incentives, there were some who saw little value in such action, believing that they would end up paying for it through some form of additional taxation.

Some plants feel a need for improved legislation to facilitate waste reduction and reuse. One representative in particular wishes to see a standardization of municipal, provincial and federal legislation covering the entire area of pollution control.

There was a greater percentage of negative opinions expressed concerning activities 2 and 4. In fact, only for proposed activity 4 did negative views out number the positive ones. This response is due to the fact that many of those interviewed were aware of the existence of the Canadian Waste Materials Exchange program and saw no need for a duplicate service.

The relatively large negative response to the possibility of a mobile waste reduction service being provided by OWMC would appear to be due to a lack of understanding of what operations might be included in such a plant.

It is apparent from this survey that there are some sections of the fabricated parts industry which do not have a real waste problem. However, it is equally apparent that plants involved with electroplating, acid treatment and coating operations do have a waste problem and are interested in any service OWMC might provide to help them reduce or solve this problem. It is felt that a similar survey narrowed down to such plants would yield more concrete information regarding OWMC roles.

5.5 TRENDS IN WASTE QUANTITY AND QUALITY

The overriding factor affecting trends in the quantity and quality of wastes generated by the fabricated metal parts industry in Ontario is the Canadian economy. This survey was carried out at a time when plants were experiencing a considerable decrease in demand for their products. Many of those interviewed had reduced manpower by as much as 40%, and saw little prospect of the situation improving in the immediate future.

The economy can also have an effect on the amount of waste recycled or recovered. For example, the recovery of a particular metal from an electroplating waste stream may be economically viable when there is a heavy demand for it on the Canadian or international market. However, once that demand slips below a certain level, it becomes unprofitable to recover it from the waste stream. Fluctuation in the price of metal has a large bearing on what the electroplating industry recovers from its waste streams and what it dumps. At the moment, the demand for most metals is low, and so the economics of metal recovery must be examined carefully. Another factor which affects the recovery potential for a particular plant is the required purity of the recovered metal.

Many municipalities are now enforcing stricter waste discharge limits, as well as increasing treatment surcharges. This is becoming a major consideration for plants contemplating the installation of recovery or recycle processes.

Treatment of metal finishing waste by neutralization followed by gravity settling for separation of suspended solids - with additional steps for hexavalent chromium and cyanide - is widely used in the electroplating industry nowadays. This treatment method results in a heavy metal sludge which must be disposed of. With more electro-platers thinking of metal recovery, especially by evaporation, electrochemical, ion exchange on reverse osmosis techniques, the prospect of a much smaller volume of heavy metal sludge is real.

More platers are becoming conscious of the amount of water used in rinsing and many are implementing stricter housekeeping practices, using conductivity cells to avoid excess dilution in the rinse tanks and employing spray rinses to minimize rinse water use. However, the major water conservation technique for this industry is the use of multiple counterflow rinse tanks. By applying a closed-loop chemical recovery system to a plating operation, the need to treat the rinse water normally associated with that step is eliminated. As these techniques are increasingly applied, the volumes of waste going to treatment will be reduced.

Some platers are moving towards the use of non-cyanide baths to avoid the problems associated with the disposal of cyanide waste.

Looking at the fabricated metal parts industry as a whole, many users of difficult solvents such as trichloroethylene seem to be moving towards the use of less toxic solvents or detergents. Also, paint manufacturers are reducing the amount of solvents in paint, with water-borne coatings becoming increasingly popular.

For these who are major waste generators, there is a definite trend towards waste reduction, reuse and recycle. However, for many of the small to medium size operations, some outside assistance is required to enable them to reduce their waste, and stay in business at the same time. Most toxic waste generators today know they have a waste disposal problem and many have an idea how to solve it, but, to do so within the financial constraints of that company, is the challenge that faces them.

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6.0 RECYCLING INDUSTRY IN ONTARIO

An extensive recycling industry exists at present in the province of Ontario. For the purpose of this study, only that part of the industry was surveyed which deals with liquid industrial wastes and industrial sludges and residues. In addition to this part of the industry, an extensive network of "scrap dealers" exist who deal in the following commodities:

- Scrap Ferrous Metals
- Scrap Non Ferrous Metals
- Waste Paper of all Grades
- Waste Textiles, Rubber and Leather
- Scrap Thermoplastics
- Used Pallets
- Used Drums.

Since none of these commodities will be of much concern to OWMC, no attempt was made to survey these recyclers.

A total of 25 companies were contacted; of these, two were out of business and one was wrongly listed as a recycler, (they deal only with in-plant wastes). The 22 remaining companies are shown in Table 6-1 (page 6-2). The survey questionnaire utilized to interview these 22 companies is appended to this report (Appendix B).

Of the types of waste which are of interest to OWMC, there exists a recycling market for four main streams. These are:

- Waste Oils
- Oily Water
- Solvents, and
- Spent Pickle Acid.

TABLE 6-1 - ONTARIO RECYCLING COMPANIES SURVEYED

Company	Location	Telephone No.	Contact	Year Established	Approx. No. of Employees
Anachemia	Mississauga	(416) 279-5122	George Wentlandt	1956	35
Breslube	Breslau	(519) 648-2291	Frank Wagner	1977	50
CanAm Oil	Breslau/Toronto	(519) 648-2226	Dale Schofield	1949	75
Chem Ecol	Cobourg	(416) 372-2251	Brian Milner	1975	12
CPW	Barrie	(705) 737-3411	Jim Stewart	1976	30
Eagle Brook	Toronto	(416) 469-4136	Abby Nash	1981	20
Fisher Goldsbie	Toronto	(416) 781-1730	C. Goldsbie	1952	10
Freedman Associates	Toronto	(416) 222-4894	Herb Freedman	1975	1
Johnson Matthey	Brampton	(416) 453-6120	Dave Burger	-	30
Metal Recovery Industries	Hamilton	(416) 549-9894	Ed Rogers	1961	25
Mosaic Chemical	Mississauga	(416) 625-9437	Cliff Holland	1982	2
Oakside Chemical	London	(519) 681-1103	Sharon Kelley	1975	3
Petroleum Recycling	Toronto	(416) 881-9880	Mel Ash	1975	12
Precious Metals Recovery	Kitchener	(519) 893-2730	Neil Nicholls	1979	10
Retek Resource Recovery	Brantford	(519) 756-9770	John McNeill	1981	3
Rothsay Concentrates	Mississauga	(416) 823-6550	Bill Vanderland	1976	4
Scandex	Kitchener	(519) 893-0840	Jorma Braks	1979	10
Shell Oil	Toronto	(416) 597-7110	Dave Fisher	1979	35
Thomscan	Mississauga	(416) 625-9436	Alex Thomas	1981	4
Van Waters & Rogers	Toronto	(416) 741-9190	Ken Cook	1973	4
Varnicolour	Elmira	(519) 669-3318	S. Argenton	1962	4
Whisper Trading	Toronto	(416) 536-9617	Shawn Doyle	1980	1

In addition to these four major waste streams being recycled, minor recycling activity occurs in the following waste stream categories:

- tin bearing liquids and sludges
- precious metal bearing liquids and sludges
- photographic chemicals and film
- paints
- laboratory chemicals
- dyestuffs

Table 6-2 shows the number of companies surveyed involved in recycling the four primary waste streams, and the approximate annual amounts involved.

TABLE 6-2 PRIMARY WASTE RECYCLING ACTIVITIES 1982

Recycled Waste	Number of Companies	Approximate Annual Volume (million litres)
Waste Oils*	6 (4)	112.5 (81)
Oily Water	4	25.2
Solvents	6	33.75
Spent Pickle Acid	2	108.0

* (2 of the companies reporting only partially upgraded oils, some of which are then sent to 2 of the 4 other companies.)

Quantities for the minor waste recycling activities are shown in Table 6-3

TABLE 6-3 MINOR WASTE RECYCLING ACTIVITIES 1982

Recycled Waste	Approximate Annual Tonnes
Tin Bearing Sludge & Liquids	60-80
Photographic Waste*	more than 120
Other Precious Metal Bearing Sludges	50-100
Paints	50
Laboratory Chemicals (mainly solvents)	60
Dyestuffs	6

* (Total not exact since one company was not prepared to disclose quantities of waste handled.)

In each of the sections which follow, a brief profile of the recycling industry for each of the waste streams is given.

6.1 OILS

The oil recycling industry in Ontario consists of 6 major firms who handle about 112.5 million litres/year of waste oils and employ about 160-180 people.

There are two re-refiners in the province, one using the classic acid/clay re-refining process, the other using a substantially modified version of the PROP process. These two re-refiners estimate that they process about 67.5 to 72 million litres/year of used lubricating oils, of which about 40.5 to 45 million litres are generated in Ontario.

There are two companies which specialize in re-refining specialty industrial lubricating oils, hydraulic fluids, and heat exchanger fluids. Of these two companies, one does 90% of its business in mobile plants which are taken to a customer's premises where they clean up the contaminated oils which are directly returned to the customer's inventories. The second company, while not using mobile equipment, offers essentially the same service. Almost all of their business is done on a "toll" basis - the customer's contaminated oil is taken to the recycler's plant, cleaned up and returned to the customer for reuse. Both of the specialty oil recyclers take a small percentage of oils which they have to market after clean-up. The volume handled by these two recyclers is about 13.5 million litres/year, most of which is from Ontario.

The other two recyclers who handle oil as a major part of their business, do only a minimum amount of processing, generally only removing water and any major solid contaminants. These two companies then market the oil to the two major re-refiners or to companies using waste oil for road oiling or as a fuel.

Road oiling and direct combustion as an energy source are alternate outlets for used lubricating oil. These uses of the material are becoming economically less attractive. The value of lubricating oils is increasing rapidly and the value, therefore, of re-refined products is also increasing. The re-refiners are offering up to 11¢/litre for reasonably clean oil. This would be equivalent to about \$3 to \$3.50 per million Btu if the oil were used as a fuel. While this is lower than the cost of No. 2 fuel oil or natural gas, it is higher than coal or residual oil would be for a large industrial user. At 11¢ per litre, this is also a rather expensive dust suppressant. A proportion of the available waste oils are considered un-re-refinable; these will continue to be used for road oiling or used as an energy resource.

All but one of the companies surveyed felt that the quantities of waste oil that they would handle in the future would increase. The sixth company indicated that they anticipate a slight decline in their particular market share. The general optimism about the increase in volume of waste oils being recycled was attributed basically to the following:

- Increased markets for recovered products
- Increasing cost of disposal
- Increasing cost of raw materials
- Aggressive marketing by the recyclers
- Industry being more aware of recycling services available

While this overall optimism exists about growth in the industry, one major oil company has recently discontinued plans to build a re-refinery in Ontario.

In response to the question of whether government initiatives were increasing the quantities of oil going to recycle, all companies surveyed offered the opinion that this was not the case. In fact, several indicated that there were some government initiatives which were being counter-productive. Problems cited were:

- Insufficient controls on road oiling. High concentrations of contaminants such as PCBs, heavy metals, etc., in some oils used for dust suppression.

- Recent moves by MOE to allow the use of waste oils in heating units in service stations and greenhouses felt to be counter-productive to the encouragement of increased re-refining. MOE report that this is only applicable to service stations which are too far from a re-refinery to make it economic to collect their oil.

- There is a 12% duty charged on waste oil brought in from the United States, limiting the expansion of one major re-refiner into taking more waste for recycling.

- In Canada, unlike the United States or most European countries, re-refined oils are subject to similar taxes as those on new oil. This reduces the economic benefits to be gained by using a recycled product.

In response to a question on what will be the major barriers to even greater activity in oil recycling, the two responses most cited were:

- Government legislation and/or lack of it, as discussed above.

- Capital costs for plant expansion could become a limit to the growth of a couple of firms. This may have also been the cause of the withdrawal of plans by a major oil company to build an Ontario re-refinery.

In response to questions on residuals from the oil re-refiners, only one reported any material which was being disposed through licensed industrial waste disposal facilities, and this amounted to only 2-1/2 tonnes of sludge from an oil pretreatment process; that sludge was being shipped to the United States.

The biggest of the re-refiners produces a sewerable waste water stream and a black asphaltic filter cake which is blended into the company's asphalt product of their crude oil refinery.

The mobile oil cleaner is producing sewerable wastes and very small quantities of solid waste, which is accepted for disposal in municipal landfill sites. Even the company using the old acid clay process for re-refining finds that it has no difficulty in meeting the regulations for disposal in a municipal landfill site. Were the regulations to change, approximately 3,000 tonnes/year of acid and clay sludges would require disposal at OWMC's facilities.

Opinions on the role of OWMC in encouraging recycle are discussed in the final section of this chapter. Opinions from the oil recyclers reflect the pattern discussed in that section, except that a much stronger positive opinion was expressed about OWMC lobbying for changes in government regulation (a) to eliminate taxes and duties on re-refined oil products, and (b) to tighten regulations on alternative uses of waste oils such as for fuels or for road oiling.

In summary, the Ontario waste oil recycling industry appears to be well established to deal with both waste crankcase oils and specialty industrial lubricating, heat transfer, and hydraulic oils. Services provided by the industry include:

- Waste oil collection
- Waste oil re-refining
- Specialty oil cleaning at a fixed processing plant
- Mobile equipment for specialty oil treatment at the plant in which the oils are used.

6.2 OILY WATER

Four companies involved in the treating of various oily water mixtures were surveyed. The wastes which they handle range from small quantities of wastes which contain high concentrations of oils to larger quantities of emulsified or even soluble oils. They employ a variety of physical and chemical techniques to divide these streams into a recoverable oil product, a sewerable water stream, and a dewatered sludge containing any solids which were in the original wastewater. Chemicals are added for emulsion breaking and for pH adjustment. Simple settling, centrifugation, ultrafiltration and filtration using precoated filters in filter presses are typical of the different unit operations which are applied to different waste feeds.

The four companies surveyed process about 25.2 million litres per year and employ approximately 30 to 35 people. A portion of the recovered oil is sold to re-refiners. Much of it, however, is used for road oiling. Because of the varied nature of the wastewater feed, it was difficult for the survey respondents to estimate what percentage of the influent volume was recovered as reusable oil. Most agreed that 5 to 10% of the influent value was "not a bad estimate", which would mean an annual volume of about 1.26 to 2.52 million litres of oil, the majority of which is used for dust suppression. The typical quality of the recovered oil is a product containing 85% oil and a maximum of 15% residual water and dirt.

Estimates of the residual sludge produced ranged from 0.8% to 5% of the influent, which would mean a range of 224 to 1,400 tonnes per year for disposal from all of the companies surveyed. None of the companies have found difficulty in meeting the regulations for environmental acceptability of this solid waste for disposal in municipal landfills. All of the companies surveyed had not encountered any difficulty in cleaning the water to a quality which was acceptable for discharge to a municipal sewer system.

The general opinion on the prospects for growth in this branch of the recycling industry was quite positive. The present downturn in the economy was having a marked negative effect on their business volume, but this was thought to be of a temporary nature and entirely attributable to the present economic difficulties decreasing primary industrial activity, thus reducing the volumes of industrial wastewater produced.

There was some variation in the reasons attributed to the optimistic outlook on volumes. This was particularly so in the case of costs of alternative disposal and government action to stimulate recycling. Diametrically opposite views were expressed on the cost of disposal. One company thought that this was increasing their business, while another felt that the cost should have been escalating much faster for his business to grow at the rate which he felt it should. Several companies felt that government regulations were increasing their volume of wastes, while another expressed the opinion that much tougher legislation and policing of legislation was required to increase the quantities of oily wastewater going for recycle. All of those surveyed felt that growth in their industry was limited by insufficient supply; none expressed any difficulties in readily finding markets for any recovered products.

6.3 SOLVENTS

The seven most active solvent recyclers in Ontario were surveyed during this study. They handle an annual volume of about 33.75 million litres and employ 80 to 90 people.

The major volumes of solvents handled are from paint clean-up operations and chlorinated solvents from a variety of operations including degreasing. Smaller volumes of a larger number of different solvents are also handled.

Of the 33.75 million litres handled by the companies surveyed, about 3.75 million are handled by two companies who specialize only in collection of solvent wastes for recycle. These are then sold to the companies actually involved in recycling, so some degree of double accounting is involved in the 33.75 million litre total. Of the, perhaps, more realistic total of 30 million litres, 13.5 million litres are partially cleaned by one company, and marketed as a fuel, while 16.5 million litres are reclaimed for reuse by 4 companies.

The great majority of this 16.5 million litres is reclaimed on a "toll" basis; that is the solvent is taken from the primary producer, cleaned and returned to the primary producer and a fee or toll charged for the service. A certain amount is purchased by the solvent recyclers and marketed by them independently.

Two of the four companies who actually reclaim solvents for reuse concentrate on paint wash-up solvents. These are highly contaminated solvents which have been used to clean painting equipment between colours, or paint mixing equipment between batches. One of these companies uses a simple batch pot still for recovery, while the other utilizes a wiped film evaporator, with a simple condensation system. Neither employs any fractional distillation techniques; the mixed paint wash solvent is recovered as a reclaimed mixed solvent product. One of these two companies, however, pointed out that great care was taken to ensure that the wastes from different companies were kept separate and only the recovered product from a particular company's wastes was returned to that company. An intimation was made that this was not always the case within the industry.

One company specializes in chlorinated solvents, and, in fact, does not have any processing facilities in Ontario. Wastes collected in Ontario are shipped to Quebec for recovery, and reclaimed product returned either to the company generating the original waste, or sold to others. Separation of waste solvents into individual chlorinated chemical species is practised by this company, in comparison to the recovery of mixed paint wash solvents discussed above.

The fourth company is the most diverse in the waste solvents which it accepts and in the recovered products which are returned to the generators or available for sale to other users. They process hydrocarbons, alcohols, ketones, chlorinated and fluorinated solvents, glycols and heat exchanger liquids. This company has 6 stills, two of which have fractionating columns to separate mixtures of solvents. This one company seems to have the greatest flexibility to handle bulked material from smaller sources such as from one of the two collection services which specializes in laboratory chemical waste disposal.

The efficiency of recovery from the influent solvent waste varies from about 90-95% for the operations which recover paint wash solvents or recover a high calorific value fuel product to as low as 70 to 75% for the companies specializing in recovering pure single solvent species. This, then, results in the generation of about 5 to 25% of the influent volume as a sludge. The fate of this sludge varies widely. In only one case is it directly sent to a municipal landfill site.

One company utilizes the majority of its sludge as a fuel in its steam boilers. This provides 60 to 70% of the energy required for the operation of the distillation process. An occasional load of excess sludge is sent to the United States for disposal.

One of the two paint wash solvent reclaimers is examining the possibility of utilizing still bottoms as a low grade paint or varnish. For the present, the still is being run until the solids concentration in the sludge is sufficiently high that it will set up as a solid after removal from the still. This is then landfilled as a bulk solid or in drums.

The remaining two companies who have processing facilities in Ontario dispose of sludges to Tricil or to approved facilities in the United States. The total quantity of sludge not now used for heat generation, and which might, therefore, require treatment and disposal at OWMC facilities, is about 1,500 to 2,000 tonnes/year. This material can be generally described as a highly viscous sludge containing quite high concentrations of solids, some of which may contain heavy metals. One of the major problems associated with this material will be in designing effective materials handling systems for dealing with tote buckets or drums full of this very viscous sludge.

The general opinion among the companies surveyed was that their business would increase as soon as the economy started to improve. One dissenting voice suggested that he felt that the activity would decrease due to increased in-house recycling of solvents by industry itself.

The reasons for the increase in business most often cited by the solvent reclaimers were, in descending order:

- The cost of disposal is increasing
- Industry is more aware of recycling services available
- The cost of raw material is increasing
- Aggressive marketing of services
- An ability to give vary favourable economic terms
- Government action to stimulate recycling.

For those companies not strictly operating on a toll basis, the general opinion was that even greater growth would be limited by a fairly limited market for recovered products.

6.4 PICKLE ACID

Two companies were contacted during the survey who deal in spent pickle acid from steel pickling operations. These two companies handle a total of 108 million litres/year and employ about 25 people.

Sulphuric acid has traditionally been used as a pickling acid for the cleaning of steel prior to tin plating, galvanizing or other surface treatment. Some of the larger steel companies have switched to hydrochloric acid because it allows for regeneration of the acid and the formation of a by-product, iron oxide. The ferrous chloride is broken down by the application of heat and reaction with water to hydrogen chloride gas and iron oxide:

$$2FeCl_2 + 2H_2O + \frac{1}{2}O_2 \text{ --- } Fe_2O_3 + 4\,HCl$$

The hydrogen chloride gas, when absorbed in water, can be reused as fresh pickle acid. The iron oxide product can be potentially reused in applications where a very pure iron oxide is required, such as in the production of recording tapes. While the potential for total recycle exists, even those companies with regeneration facilities waste a certain proportion of their spent pickle acid.

Large quantities of spent acids are available. These typically contain 15-25% iron salts, and 1 to 4% free acid. The recycling companies work with the steel picklers to try to set standards for the pickle acid. It is desirable to minimize the quantity of free acid remaining in the liquor, while maximizing the quantity of iron salts. Free acid levels of 1 to 4% are typical. The level of free acid can be reduced by the addition of iron to the solution.

Some of the pickle acids which contain a very high concentration of iron salts are treated to crystallize out the iron salts as a solid product. The vast majority of these liquors, once the free acid levels have been adjusted, if necessary, are sold to wastewater treatment plans for use as a flocculating agent.

A new development, being explored by the two recycling companies, is the transfer of spent acid from aluminum anodizers, which still has a fairly significant concentration of free acid, to steel picklers as a feed pickling acid. This is an excellent example of two step recycling - a waste from one company being used in a second industrial process, after which it is then recovered for use in wastewater treatment. The aluminum content of the final spent acid will be beneficial at the wastewater treatment plant, as alum also acts as a flocculant.

A problem area is the spent acid from galvanizing operations. These acids tend to be highly contaminated with zinc, thus rendering them unacceptable for use in wastewater treatment plants. The recycling companies are working with the galvanizers to minimize the quantities of unusable acids, through separation of clean steel pickling acids from acids used later in the process. While some developments in technical approaches to zinc removal have been reported this was mentioned as an area in which some further research effort would be extremely helpful.

The response to questions on the trends in quantities of waste being recycled was mixed. There has been a shift of business from one company to the other, and the present state of the Canadian steel industry is depressing the quantities of wastes available. The 108 million litres/year figure was the expected quantities in more normal economic times.

The reasons given for an increase in business by the one company, in descending order of importance, were:

- Aggressive marketing efforts
- Cost of disposal by other means is increasing
- Ability to give more favourable economic terms
- Industry is more aware of recycling
- Production will be increasing (after the recession).

The eventual barrier to even greater expansion was considered to be that there is only a limited market for the recovered product, within a reasonable transportation distance. Additional markets might be served if greater quantities of the iron salts were crystallized out of solution as a solid product for shipping to other provinces or the United States.

6.5 MISCELLANEOUS WASTE STREAMS

Seven companies were surveyed who deal in miscellaneous waste stream recycling. Four of these companies are associated with metal bearing sludges and liquids. These are restricted to high value metals such as silver, gold, platinum and tin. All of the metal recyclers deal mainly with solid waste, such as scrap tin plate, photo negatives and film, and recovered solid precious metals. Since these solid wastes do not fall into the liquid industrial and hazardous waste categories which are of interest to OWMC, only the minor parts of their businesses, which involve sludges or liquids, were discussed.

The remaining three companies surveyed included one company disposing of laboratory wastes, and two brokers who deal in a number of solid and liquid industrial wastes including paints and dystuffs.

These miscellaneous recycling operations are discussed briefly below:

Tin Sludges

Approximately 60 to 80 tonnes/year of tin bearing sludges and liquids are treated in Ontario for the recovery of tin. Scrap tin plate is treated with caustic soda to solubilize the tin. This solubilized tin stream, along with liquids containing tin and tin sludges, are treated electrolytically to recover the tin from solution and to regenerate the caustic soda for recycle to the detinning baths. The residues from the detinning and tin recovery operations are a detinned ferrous scrap which is sold to the steel mills, and a black "tin mud" which contains about 8% insoluble tin which is sold to a tin smelter.

It is felt that the quantities of tin bearing liquids and sludges for recycle will be increasing, particularly if government increases the pressure on the glass industry to install scrubbers on their stacks. This will result in a tin bearing sludge or liquid being produced which could be recycled. The barriers to greater growth of this industry are entirely supply limited. There are strong markets for recovered tin as a metal or as tin compounds.

Precious Metal Sludges and Liquids

The three companies surveyed are probably treating between 200 and 500 tons/year of precious metal bearing sludges and liquids. One company did not wish to disclose the quantities of waste that it was handling.

Silver recovery from photographic waste, both solid and liquid, is expected to rapidly decline over the next few years as the photographic industry moves into silverless film products.

Recovery of precious metals from plating solutions was felt to be increasing in quantities. For one company, this was felt to be a marginal operation undertaken mainly as a service to its customers for their precious metal products. Generally, the liquids contain cyanide and require proper disposal after electrolytically recovering the precious metals from solution. Treatment of the cyanide by alkaline chlorination results in the production of a sludge, and a sewerable liquid. The sludge may contain sufficient concentration of other metals to warrant recovery in a secondary smelter. One company's sludge contains almost 50% copper.

Laboratory Wastes

There are two companies in Ontario who specialize in the disposal of laboratory chemicals. One of the two was surveyed during this study as this company is undertaking some reclaiming of solvents.

Laboratory wastes present a specialized problem for proper disposal. The problem is mainly associated with the scale and diversity of wastes to be handled. The general method for disposal is to assemble jars and vials of compatible wastes in a 45 gallon drum packed with a suitable fill material such as vermiculite. The drums are then disposed at a secure landfill.

Solvent wastes from laboratories, either in bulk drums or in glass bottles, are assembled and bulked by solvent type. The bulked drummed wastes are then shipped to one of the several Ontario solvent reclaimers. A total of 27,000 to

54,000 litres of solvents per year are reclaimed. This quantity is expected to grow quite rapidly as the company's business grows. A small quantity of residue is produced from the settling of solids from the solvents. This material is solidified and is accepted for disposal in a municipal landfill site.

Paint and Dyestuffs

Two brokers were surveyed who deal in a number of different wastes, some of which are solid and non-hazardous and, therefore, not of interest to OWMC. The two types of commodities which could be of interest to OWMC are paints and dyestuffs. Trading in out-dated dyes and overstocked paints was estimated to amount to approximately 7 to 8 tonnes/year in dyes and approximately 45,000 litres per year of paints. These are marketed directly for use in non-critical applications, and, in some cases, exported. The trends in quantities to be handled are very difficult to predict; they vary from year to year.

6.6 POTENTIAL ROLES FOR OWMC IN STIMULATING INCREASED WASTE RECYCLING

In questioning the industry on what useful roles OWMC might play to encourage the recycling of material, and in generally stimulating activity in their industry, eight potential roles were suggested. These are shown below with the number of positive responses to each noted, out of the 22 surveys conducted.

Suggested Potential Role for OWMC	Number of Positive Responses
1. Providing a referral service on recycling companies in Ontario who might be able to deal with an industry's wastes.	18
2. Facilitating or providing financing for the development of waste recycling facilities.	9
3. Encouraging government to establish regulatory or tax incentives to encourage the reuse of recycled materials.	12
4. Undertaking or sponsoring research and development in the area of waste recyle.	16
5. Bulking of small quantities of wastes and auctioning the bulked materials to the existing recycle industry.	5
6. Installing equipment for the recycling of waste streams not now adequately dealt with by the private sector.	2

Suggested Potential Role for OWMC	Number of Positive Responses
7. Providing an information service to the recycling industry on the latest technical developments in recycling.	15
8. Providing an information service on potential users of recovered materials and on sources of waste streams for recycle in Ontario. This might be in conjunction with the Canadian Waste Materials Exchange.	19

From these responses, there seems to be: general agreement on the usefulness of potential roles 1, 4, 7 and 8; some fairly strongly voiced negative opinions on potential roles 5 and 6; and a more or less neutral feeling on roles 2 and 3.

The most positive opinions expressed were on the idea of referring people to the existing industry and sponsoring of research and development to improve technologies available to the recycling industry. The high proportion of positive responses on "The technical information service on developments in the recycling industry" and on the "Waste Exchange service" might be better described as "non negative" votes. Most felt that they were already keeping up with developments through their own reading and through their industry associations. The companies surveyed in the recycling industry were all aware of, and participating in, the Canadian Waste Materials Exchange program, and felt that it was doing a reasonable job, so wondered how this program was going to be integrated with any initiatives of OWMC.

Some quite negative opinions were offered on the need for, and roles of, OWMC in the recycling industry. A genuine concern was expressed by many on the bulking of small quantities of waste materials for subsequent transfer to the recycling industry. A majority of those surveyed prefer to know precisely the source of the material which they process, and to be sure that unacceptable contamination of their feed material does not occur.

The predictable negative opinion on OWMC installing equipment for the recycling of wastes not now adequately dealt with by the private sector, and the somewhat more surprising negative opinion on OWMC providing financing for the development of waste recycling facilities, is a reflection of the fiercely entrepreneurial, private sector, nature of the recycling industry.

In summary, the recycling industry has a generally negative attitude toward the need for any OWMC involvement in their industry. The two potential roles, for which the most positive opinion was expressed, were:

- Providing a referral service on recycling companies in Ontario who might be able to deal with an industry's waste.

- Undertaking or sponsoring research and development in the area of waste recycle.

Three specific research needs were suggested during the survey. These were:

- The recovery of zinc from the spent galvanizers' acid waste.

- Investigate the potential use of sludge from paint wash solvent recovery as a low grade paint product.

- The economic recovery of base metals from treated electroplating sludges.

7.0 WASTE REDUCTION EFFORTS IN OTHER JURISDICTIONS

Most Provincial and State governments have recognized the importance of reducing the amount of hazardous waste generated by encouraging waste recycling and reuse. However, few programs have developed to the point of those in the States of New York and California. In each case, the programs have been helped along by legislation requiring industries to participate. In addition, the governments have made formal moves to limit the amount and types of wastes that can be landfilled. Because of the amount of experience gained in recycling of hazardous wastes within these innovative programs, they have been selected for further discussion in this section. Many programs have been modelled on these efforts. They should offer interesting items to be considered in developing the program further here in the Province of Ontario.

7.1 NEW YORK STATE PROGRAM(1)

The State of New York realized that a significant amount of its industrial hazardous waste was going directly to land disposal facilities in the Niagara frontier. In order to curb this trend and promote hazardous waste reduction, legislation was enacted to encourage activities which would reduce those waste streams which may pose environmental and health problems when disposed in a landfill and provide a positive business climate for the State's industries. The Industrial Materials Recycling Act (IMRA) was enacted on July 13, 1981 (Chapter 990 of the Laws of 1981, New York State). It assigns the responsibility to establish a comprehensive program to assist the industries that generate industrial wastes in order to encourage the reduction, recovery, and recycling of these materials to the New York State Environmental Facilities Corporation (EFC). The EFC is dependent on funding from the State legislature and grants from the Federal government for its programs. Its programs must compete for funds with other programs in the State on an annual basis.

Under the IMRA legislation, there are some important definitions which must be kept in mind when attempting to compare the New York State experience with that in Ontario. The definition of industrial materials includes both industrial hazardous waste and industrial solid waste. Excluded are solid or dissolved materials in domestic sewage, solid or dissolved materials in irrigation return flows or industrial discharges subject to permits under the Environmental Conservation Law, and special nuclear or by-product materials as defined in the Atomic Energy Act of 1954.

The EFC is a public authority established under the New York State Public Authorities Law. It has had a variety of roles over the years, generally related to its ability to grant loans to private industry for air and solid waste management facilities. EFC has also been active in coordinating Federal grants to municipalities for construction of sewerage treatment facilities. Its specific responsibilities in this IMRA program are outlined in Table 7-1. The programs developed by the EFC to meet these responsibilities are briefly described below.

Waste Exchange

To provide a waste exchange catalogue, and to avoid the duplication of services already available, EFC contracted with the Northeast Industrial Waste Exchange (NIWE) to help subsidize continuing publication of a quarterly catalogue. The NIWE effort has been initiated by the Central New York Regional Planning and Development Board and the Manufacturers Association of Central New York. The EFC is making extensive use of this catalogue to both identify and pursue those waste streams with exchange potential. Periodic articles and supplements are prepared by the EFC staff for distribution with the catalogue.

The EFC is currently evaluating the feasibility of initiating an active waste exchange. A chemical engineer with industrial experience has been retained on the EFC staff for this purpose. Conceptually, this program would work as follows: A method of identifying wastes listed on the industrial waybills which may have potential users would be developed; then direct contacts would be made with potential users; then the generator would be contacted to see if a "match" could be made.

Information Activities

The EFC established and maintains a technical information library. This not only serves as an important resource for staff conducting research but can also be used by individuals and companies interested in waste reduction and recycling. Technical data base searches and computer print-outs referencing the latest materials available on related topics are available through EFC.

The EFC has also developed a newsletter, "Industrial Materials Recycling Program Status Report", to disseminate valuable information which it has obtained to industry, trade associations, government officials, members of the public environmental interest groups, as well as other interested parties. This newsletter is designed to provide this ongoing summary as well as to provide a means of exchanging technical information between these groups.

In implementing the information activities program, EFC has met with numerous interest group and individual companies to explain the IMRA program. EFC staff also make numerous presentations at meetings throughout the State so a wide range of interests can be reached. A number of requests for assistance have resulted from this activity.

Technical Assistance

With the assistance of a grant from the U.S. Environmental Protection Agency, the EFC published "A Preliminary Handbook on the Potential of Recycling or Recovery of Industrial Hazardous Wastes in New York State". This preliminary handbook provides information on the technical and economic feasibility of reusing and recycling various waste streams identified as hazardous wastes in New York State. The material is presented in tabular form and indicates waste types and the general industrial sources of the waste by SIC, the potential types of available recycling technologies, and the potential value of such recyclable materials.

Other elements of the Technical Assistance Program include:

- Per diem consultants are used to address specific issues that have been identified on an industry-wide or individual company basis by EFC staff. Two professors from Rensselaer Polytechnic Institute experienced in a variety of industrial processes have been assigned the responsibility of directly assisting industries. Additionally, they will assist in reviewing waybill data in an effort to determine the possibilities for active waste exchange "matches", where potential reuses and users can be identified.

- Within the time limits and capabilities of the staff, direct assistance is given to industries, specifically in the areas of defining problems and suggesting management courses of action which could be followed.

- Continuous review of various data base searches available to EFC through the State Library system is being done to identify information resources and acquire both general knowledge and information on specific problems.

Confidentiality

Because of the nature of the activities and the requirements of the law, EFC has gone to great efforts to establish specific procedures to safeguard trade secret information which might be submitted in the course of its activities. Secure areas have been designated and are in use, and procedures established to handle material, with limited access granted to only those individuals directly concerned with the information. Confidentiality has also been extended to the activities of the nine firms with whom EFC has contracted for the waste exchange data log. Shielding is provided to protect the identities of individuals submitting information until such time as both parties agree to have their identifications made available to each other.

Program Evaluation

Under IMRA, it is EFC's responsibility to submit a report to the Governor and the Legislature on the effectiveness of this program, with detailed evaluations of program elements and recommendations for continuance of the program. EFC is hopeful that these program evaluations will show a significant reduction in waste stream quantities. While the actual quantities reduced may be a small percentage of the total waste produced state-wide, the program is seen to be an effective tool in handling the various kinds of wastes being generated within the State. By providing industries with technical assistance in those particular areas in which they are not equipped, groundwork can be laid for a positive framework to encompass both environmental and health aspects as well as the State's commercial climate.

7.2 CALIFORNIA PROGRAM (2,3,4)

In the State of California there were two active public groups involved in waste reduction. The Office of Appropriate Technology (OAT) was established by the Governor of the State to "investigate the technological feasibility and cost of alternatives to burying toxic wastes in landfills and to recommend ways to reduce the volume of toxic materials disposed of in the land." The other group was the California Department of Health Services. The California Hazardous Waste Control Law required this group to:

- Maintain a technical reference on hazardous waste recycling practices
- Investigate market potential and feasibility of recovering resources from hazardous wastes
- Promote waste recycling;
- Encourage reducing or exchanging hazardous wastes
- Maintain an information clearing house on recyclable hazardous wastes.

In addition, the Department prepares a list of hazardous wastes that can be recycled economically, and it has the authority to require a detailed justification from anyone who disposes of a waste product on a recycling list. Recently OAT has been merged into the Hazardous Waste Management Branch of the Department of Health Services (DHS) so these complementary functions could be managed more effectively. The programs developed in the area of hazardous waste reduction are briefly descried below:

List of Wastes Considered Feasible for Recycling

The California Hazardous Waste Control Law requires DHS to maintain a list of hazardous wastes that are economically and technologically feasible to be recycled. This list was recently expanded and can be found in Table 7-2. Review of the literature and experience within the program is utilized to keep this list up to date. This appears to be the only legislatively formalized list of its kind in North America.

Letters of Inquiry

The DHS is authorized by the law to issue letters of inquiry to generators of hazardous waste. According to the "Report to the 1982 Legislature on Recycling of Hazardous Wastes in California", approximately 23,000 manifests were examined in 1981 to identify potentially recyclable wastes which were being disposed. A total of 404 letters were sent to waste producers requesting written justification for not recycling their wastes. A total of 334 responses were received. This compares favourably with 1981 in which 12,000 manifests were reviewed and 98 letters sent out. In 1981, 69 firms successfully initiated programs to recycle and/or reduce their wastes as a result of the Department's effort; 188 firms reported that it was not feasible to recycle their wastes. The results are detailed in Table 7-3.

Waste Exchange

The DHS runs an informational waste exchange. This allows DHS to work directly with the waste producers and recyclers to help effect successful waste transfers. Inquiries received from this activity together with information obtained from DHS field enforcement and abandoned sites staff led to 36 successful waste transfer efforts. Table 7-4 details these exchanges. It is interesting to note that the DHS Waste Exchange runs contrary to the notion that private agencies alone can successfully operate these efforts. However, it is the legal/regulatory climate in California that permits this exception to the rule.

The waste exchange identified a total of 87 firms that recycle waste material. This list has proven to be highly beneficial in promoting recycling. Copies of this list are sent to waste generators who were identified as not recycling their wastes. Contact with a commercial recycler is a key element in demonstrating to DHS that the disposer's waste is not capable of being recycled.

Plans are in the works to issue a bi-monthly newsletter/catalogue. It will discuss the regulations and generally promote recycling by giving examples of successful recycling efforts and DHS program news. It will expand the activities of the Waste Exchange.

Technical Assistance

Before the merger of DHS and OAT, DHS sponsored OAT activities to identify viable alternatives to land disposal. This activity also resulted in a better knowledge of the amount and type of waste being generated, the leading industrial waste generators, amounts of waste capable of being recycled as well as technology and costs involved to treat. The OAT report was used as the basis for Governor Brown to issue his Executive Order B-8881 (signed October 13, 1981) phasing out land disposal of certain toxic wastes.

The DHS worked closely with the Air Resources Board and OAT to determine the feasibility of incinerating wastes in cement kilns in order to reclaim their thermal energy. A variance was provided by ARB to allow a demonstration of this concept.

A new electronic data process system was developed to:

- Keep track of commercial resource recycler's activities
- Maintain a record of each generator's waste stream and quantity
- Search California hazardous waste waybills for recyclable materials to issue a letter of inquiry.

This streamlining of functions should allow the Resource Recovery staff to increase the number of waste streams recycled.

A Technical Advisory Committee was formed to give DHS guidance in its programs. A panel of twelve persons was selected consisting of representatives from industry, environmental groups, government, and academia.

Information gathered by the DHS was exchanged by frequent staff attendance at trade shows and business organization meetings, visits to recycler's facilities, and presentation of papers at major waste conferences and in magazines and journals.

The DHS started some voluntary plant inspections with the intention of using this as a means to educate the generators in better ways of waste handling. They expect that these inspection trips can convince most generators of the need and advantages of segregating their waste and where in their manufacturing process the recyclable material can be diverted for separate containerization. Information gained in this activity can be shared through the activities described above.

Finally, the DHS has been encouraging, evaluating and promoting the application of innovative technology to render specific waste streams recyclable. The cement kiln was one example. Others include:

- Metal recovery from aqueous solutions
- Hydrofluoric acid recovery.

Program Development

The program is now entering its fourth year. Combining of the forces of OAT and DHS should help this program to be even more successful in the years to come.

TABLE 7-1

SPECIFIC RESPONSIBILITIES OF THE NEW YORK STATE ENVIRONMENTAL FACILITIES CORPORATION (EFC)

- The planning and compilation of research and development information on industrial methods and technologies and practices that will result in the reduction, recovery, or recycling of industrial materials.
- Investigation and research into the market potential and feasibility for increased utilization of recovered or recycled industrial materials.
- Collection, development and maintenance of data on existing and projected production of industrial materials.
- A review and analysis of existing industrial methods, technologies and practices relating to the generation, use and disposal of industrial materials.
- Development and maintenance of a technical reference capability on industrial materials reduction, recovery and recycling methods. Such information will be available for public and private use.
- Encouragement and assistance to industries on the technical, financial or regulatory means to reduce, recover or recycle such materials.
- Establishment of an information clearinghouse, or waste exchange, to include an on-going record of potentially recyclable materials.
- Preparation and continuous update of a list of materials which EFC finds are economically and technically feasible to recycle or recover.
- Preparation, in conjunction with industry, of a handbook on recovery and recycling to be made available to all industries upon request.
- Contracting, as may be necessary, with private industries for the purpose of having such entities undertake the activities described in the Industrial Materials Recycling Act.

TABLE 7-2

LIST OF RECYCLABLE HAZARDOUS WASTE TYPES IN CALIFORNIA

(Section 66796 of the Hazardous Waste Regulations, Article 12)

(a) Wastes of the types cited on the list of Recyclable Hazardous Wastes in subsection (b) are waste types which the Department finds to be both economically and technologically feasible to recycle.

(b) List of Recyclable Hazardous Waste Types (including examples of potential recycling methods or uses);

(1) Commercial chemical products including unused laboratory grade products (return to manufacturer or supplier or turn over to chemical salvager for resale or resource recovery; sell or barter to another consumer).

(2) Solvents, used or contaminated (reclaim, in-plant or through custom solvent reclaimer, by purification processes or rectification, ion exchange, absorption, or extraction; or if combustible, use in-plant or sell for use as energy resource for heating, cooling, or power generation), including:

  (a) Halogenated solvents such as trichloroethane, perchloroethylene, methylene dichloride, chloroform, carbon tetrachloride, Freons (R);

  (b) Oxygenated solvents, such as acetone, methyl ethyl ketone, methanol, ethanol, butanol, ethyl acetate;

  (c) Hydrocarbon solvents, such as hexanes, Stoddard, benzene, toluene, xylenes, paint thinner.

(3) Used or unused petroleum products, including motor oils, hydraulic fluids, cutting lubricants, fortified week oils, (turn over to reclaimer of motor oils and other petroleum products for recovery of petroleum components; or use in-plant, or sell for use as energy resource for heating, cooling, or power generation).

(4) Pickling liquor (recover iron salts by concentration, e.g., by solar evaporation of spent liquor).

(5) Unspent acids such as hydrochloric, hydrofluoric, nitric, phosphoric, sulphuric, in concentrations exceeding 15 percent (use directly as pickling and etching acids; in netralization of alkaline process waste streams, in manufacture of high purity sulphuric acid; or in manufacture of useful salt products, e.g., ammonium salts, calcium fluoride).

(6) Unspent alkalis, including hydroxides and carbonates of sodium, potassium, and calcium, and acetylene sludge. In concentrations exceeding 20 percent; (use directly in certain metal finishing operations; in neutralization of pickling acids and acid process waste streams; in precipitation of heavy metals; in road base formulation; in recovery of low gravity crude oil from wells; or in manufacture of useable products, e.g., calcium oxide, sulphate, fluoride, and chloride).

TABLE 7-2 CONTINUED

LIST OF RECYCLABLE HAZARDOUS WASTE TYPES IN CALIFORNIA

(Section 66796 of the Hazardous Waste Regulations, Article 12)

(7) Unrinsed empty containers of iron or steel used for pesticides or other hazardous chemicals:

  (A) Pesticide containers (return to the registrant or, if 30- or 55-gallon size, recondition, pursuant to Section 3143 of Title 3, California Administrative Code, or shred or bale, after removal of pesticide residues by solvent or chemical action or burning, for use as steel scrap).

  (B) Hazardous chemical containers (other than pesticide containers return to product supplier or, if 30- or 55-gallon size, recondition; or shred or bale, after removal of chemical residues by solvent or chemical action or burning, for use as steel scrap).

(8) Metals and metallic salts.

  (a) Metals or metallic salts containing precious metals, including gold, silver, and platinum (turn over to reclaimer to manufacture metal plating salts).

  (b) Elemental mercury (use in manometers).

  (c) Elemental lead and tin (use in the manufacture of solder).

  (e) Spent aluminum, nickel, vanadium catalysts from petroleum refinery operations, i.e., hydrogenation, reforming, hydrocracking, etc. (metals are extracted and sold to manufacture a low grade steel).

(9) Sulphur in concentrations exceeding 60 percent (use as a soil amendment or in the manufacture of sulphur dioxide and sulphuric acid).

(10) Organic monomers (reclaim in-plant by purification processes of rectification, i.e., molecular stills, or use as supplemental fuel).

(11) Soluble oils-soluble oils in concentration greater than 5 percent (for use in asphalt road construction).

Note: Authority cited: Section 25175 Health and Safety Code.

Reference: Section 25175 Health and Safety Code

TABLE 7-3

SUCCESSFUL RESPONSES TO CALIFORNIA DEPARTMENT OF HEALTH SERVICES INQUIRIES SENT DURING 1981 TO WASTE PRODUCERS

	Waste Stream Recycled	Amount Recycled, Tonnes*	Action Taken by Company
1.	Textile spirits, lactol spirits, toluene, isopropanol	175.0	In-house recycled & outside recycler
2.	Ammonium bisulphite, sulphurous acid, sulphur, water	1,273.0	In-house recycled & outside recycler
3.	Alcohols, waste oil	11.0	Outside rcycler
4.	Solvent waste, paint sludge, oil, water, alkaline solution	73.0	Outside recycler
5.	Oil	19.0	Outside recycler
6.	Oil, water	7.6	Outside recycler
7.	Sulphuric acid, iron, water	4,545.0	In-house recycled & outside recycler
8.	Oil, tetrachloroethane, trichlorcethane, methyl ethyl ketone	78.5	Outside recycler
9.	Unsaturated polyester alkyd resin, styrene monomer	32.7	Recover fuel value
10.	Toluene, acetone, methyl ethyl ketone	5.4	Process modification
11.	Heptane	7.3	In-house recycled
12.	Spent sulphuric acid	218	In-house recycled
13.	Alcohol, water	36.4	Outside recycler
14.	Acetone, alcohol	5.8	Outside recycler
15.	Waste oil, high flash point solvent, lime	18.5	Outside recycler
16.	Acetone	1.1	Outside recycler

TABLE 7-3 CONTINUED

SUCCESSFUL RESPONSES TO CALIFORNIA DEPARTMENT OF HEALTH SERVICES INQUIRIES SENT DURING 1981 TO WASTE PRODUCERS

	Waste Stream Recycled	Amount Recycled, Tonnes*	Action Taken by Company
17.	Styrene, ethyl benzene	27.3	Recovered fuel value
18.	Chevron solvent #450, iron fines, chrome metal fines, abrasive grits	9.2	Outside recycler
19.	Oil, solvent	11.0	In-house recycled
20.	Perchloroethylene, trichloroethylene	4.0	Outside recycler
21.	Water, oil	15.5	Outside recycler
22.	Aliphatic petroleum solvents	3.6	Process modification & outside recycler
23.	Methyl ethyl ketone	15.3	Outside recycler
24.	Methylene chloride, toluene, 1, 1, 1-trichloroethane, methyl ethyl ketone	10.0	Outside recycler
25.	Acetone, isopropanol	43.6	Outside recycler
26.	1, 1, 1-Trichoroethane, oil	3.6	Process modification
27.	Cooling oil, Stoddard solvent, water	56.7	Outside recycler
28.	Cutting oils, mineral thinners, tube oils, cooling oils, Freon	109.1	Outside recycler
29.	Solvent, water	72.7	In-house recycled & outside recycler
30.	n-propyl alcohol, n-propyl acetate, pigments, solvent	3.6	Outside recycler
31.	Thinner, pigment	24.0	Outside recycler

TABLE 7-3 CONTINUED

SUCCESSFUL RESPONSES TO CALIFORNIA DEPARTMENT OF HEALTH SERVICES INQUIRIES SENT DURING 1981 TO WASTE PRODUCERS

	Waste Stream Recycled	Amount Recycled Tonnes*	Action Taken by Company
32.	Phenol, benzine, oil	15.8	In -house recycled
33.	Naphthenic solvent, surfactants, water	39.5	Process modification
34.	Ethyl acetate, ethyl alcohol, glycol ether, ink	6.0	Outside recycler
35.	Isopropanol, n-butyl acetate	8.4	Outside recycler
36.	Paint thinner, aliphatic solvent	5.1	Outside recycler
37.	1,1, 1-Trichlorethane, methyl ethyl ketone, naptha, butyl cellosolve	21.8	Outside recycler
38.	Methyl ethyl ketone, adhesives	35.5	Outside recycler
39.	Phosphoric acid, ammonium hydroxide	36.4	Outside recycler
40.	Oil, water	10.0	Outside recycler
41.	Oil/water	7.3	Outside recycler
42.	Hydrochloric acid	21.8	Outside recycler
43.	1, 1, 1-Trichloroethane, lacquer thinner	0.57	Outside recycler
44.	Xylene, methanol	0.14	Outside recycler
45.	Motor/hydraulic oil	0.38	Outside recycler
46.	Methylene chloride	0.83	Outside recycler
47.	Trichloromonofluoroethane, trichlorotrifluoroethane	36.4	Outside recycler

TABLE 7-3 CONTINUED

SUCCESSFUL RESPONSES TO CALIFORNIA DEPARTMENT OF HEALTH SERVICES INQUIRIES SENT DURING 1981 TO WASTE PRODUCERS

	Waste Stream Recycled	Amount Recycled, Tonnes*	Action Taken by Company
48.	Skydrol oil (type 500)	5.5	In -house recycled
49.	Thinner	0.9	Outside recycler
50.	1, 1, 1-Trichloroethane	2.7	Outside recycler
51.	Methyl ethyl ketone, methylene chloride	91.0	Outside recycler
52.	Toluene	4.5	Outside recycler
53.	Oil	4.5	Outside recycler
54.	Oil	7.3	Outside recycler
55.	Oil	45.5	Outside recycler
56.	Tetrahydrofuran, toluene, methyl isobutyl ketone	607.2	Outside recycler
57.	Ferric chloride solution	341.8	Outside recycler
58.	Chevron oil, methyl ethyl ketone, acetone	3.6	Outside recycler
59.	Oil/water	223.6	Outside recycler
60.	Oil, solvents	9.1	Outside recycler
61.	Sulphuric acid	1,045.5	Outside recycler
62.	Motor oil	0.9	Outside recycler
63.	1, 1, 1-Tricholoroethane	8.2	In -house recycled

TABLE 7-3 CONTINUED

SUCCESSFUL RESPONSES TO CALIFORNIA DEPARTMENT OF HEALTH SERVICES INQUIRIES SENT DURING 1981 TO WASTE PRODUCERS

	Waste Stream Recycled	Amount Recycled Tonnes*	Action Taken by Company
64.	Isopropyl alcohol	9.1	Outside recycler
65.	Perchloroethylene	0.9	Outside recycler
66.	n-propyl alcohol	9.1	Outside recycler
67.	Ethyl acetate	9.1	Outside recycler
68.	Petroleum solvent	3.6	Outside recycler

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* Amount recycled is the total amount of hazardous waste that was recycled rather than disposed. Actual amount reclaimed is not known. All numbers are tonnes.

TABLE 7-4

HAZARDOUS WASTES RECYCLED AS A RESULT OF THE CALIFORNIA DEPARTMENT OF HEALTH SERVICES' EFFORTS

(Other than Letters of Inquiry)

	Waste Stream Recycled	Amount Recycled, Tonnes*	Action Taken by Company
1.	Methylene chloride, hexane, acetone, ethyl acetate, methanol, water	32.7	Outside recycler
2.	Calcium carbide	0.18	Outside recycler
3.	Methyl ethyl ketone, paint	44.5	Outside recycler
4.	Miscellaneous laboratory chemicals	2.5 truckloads	Outside recycler
5.	Dimethyformamide, water, methanol, dimethylamine	47.2	Outside recycler
6.	Technical grade acetone	2.6	Outside recycler
7.	Trichloroethylene	0.65	Outside recycler
8.	Hydrochloric acid	0.02	Outside recycler
9.	Potassium hydroxide	0.09	Outside recycler
10.	Trichloroethylene, sulphuric acid, silver nitrate, trichloroethane	2.3	Outside recycler
11.	Miscellaneous laboratory chemicals	12.5	Outside recycler
12.	Ink solvent and residue	12.5	Outside recycler
13.	Cyanide chemicals	0.01	Outside recycler
14.	Barium sulphate	181.8	Outside recycler
15.	Solvents	3.6	Outside recycler

TABLE 7-4
HAZARDOUS WASTES RECYCLED AS A RESULT OF THE CALIFORNIA DEPARTMENT OF HEALTH SERVICES' EFFORTS
(Other than Letters of Inquiry)

	Waste Stream Recycled	Amount Recycled Tonnes*	Action Taken by Company
16.	Mercury	0.01	Outside recycler
17.	Sulphuric acid, acetic acid, hydrochloric acid, petroleum ether	0.04	Outside recycler
18.	Pentasulphide	0.14	Outside recycler
19.	Sodium cyanide	0.6	Outside recycler
20.	Zinc hydroxide	0.55	Outside recycler
21.	Sodium	0.01	Outside recycler
22.	Sodium hydroxide, epoxy resins, amines, and isocyanates	0.65	Outside recycler
23.	Calcium hypochlorite	10.9	Outside recycler
24.	Potassium cyanide	0.01	Outside recycler
25.	Arsenic trioxide	0.01	Outside recycler
26.	Acetone	0.8	Outside recycler
27.	Calcium hydroxide	2.7	Outside recycler
28.	Toluene, isopropanol	0.44	Outside recycler
29.	Ortho-toluidine	0.01	Outside recycler
30.	Pesticide drums (empties)	150 drums	Outside recycler

TABLE 7-4

HAZARDOUS WASTES RECYCLED AS A RESULT OF THE CALIFORNIA DEPARTMENT OF HEALTH SERVICES' EFFORTS

(Other than Letters of Inquiry)

	Waste Stream Recycled	Amount Recycled Tonnes*	Action Taken by Company
31.	Paint thinner	4.4	Outside recycler
32.	Off-specification calcium oxide	15.0	Outside recycler
33.	Lime sludge	7,274.5	Outside recycler
34.	Alum mud (aluminum sulphate)	947.3	Outside recycler
35.	Catalyst fines	632.7	Outside recycler

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* Amount recycled is the total amount of hazardous waste that was recycled rather than disposed. Actual amount reclaimed is not known. All numbers are tonnes unless otherwise indicated.

7.3 REFERENCES

1. New York State Department of Environmental Conservation (1982) New York State Short-Term Hazardous Waste Management Plant. Interim Rept. for Submission to the New York State Legislature.

2. State of California (1982) A Report to the 1982 Legislature on Recycling of Hazardous Wastes in California Persuant to Section 25176, Chapter 6.5, Division 20, Health and Safety Code. Health and Welfare Agency, Dept. of Health Services, Hazardous Waste Management Branch.

3. Personal Communication, Mr. Kent Stoddard, Director, California Office of Appropriate Technology, Sept. 28, 1982.

4. Personal Communication, Dr. Robert D. Stephans, Deputy Director, California Div. of Toxic Substances Control, Dec. 30, 1982.

8.0 POTENTIAL ROLES FOR OWMC TO ENCOURAGE WASTE REDUCTION

The barriers to waste abatement, reduction, reuse and recycle can be broadly categorized under 5 headings:

- Technical Infeasibility
- Economic Infeasibility
- Lack of Legislative Encouragement
- Traditional Attitudes
- Lack of Information About Developments.

Of these, the greatest barrier is economic infeasibility. For some wastes, there is genuinely no technically feasible approach to its reduction and reuse, but, for many others, it is more that there is no economically feasible technical approach. Legislation and traditional attitudes toward processing and raw materials specifications can also generally be reduced to economic terms. If legislation allows wastes to be disposed in a municipal landfill site at $10 per tonne, there is much less incentive to look at reuse, recycle options than if the material is directed toward an industrial waste treatment and disposal site at a cost of $100 per tonne. Traditional attitudes toward raw materials specifications are similarly based on economics. When petroleum was $2 per barrel, the incentive to conserve and recycle waste oils and solvents was much less than at $30 per barrel. Another example of changes in traditional attitudes was seen in the glass industry during the 1970s. Early in the decade, when the costs of raw materials, sand, soda-ash, etc. were low, the glass companies had very strict regulations on scrap glass cullet which they would accept for remelt in the glass furnaces. No coloured glass would be tolerated in the clear glass cullet. Today, when the costs of raw materials have risen substantially, as well as the cost of energy to form the glass, the glass companies are much more interested in obtaining glass cullet. The demand for additional cullet has prompted glass companies to accept some mixed glass cullet, which previously they had suggested could not be used.

Lack of information about waste reduction opportunities can be reduced to economic terms but only in a rather round about fashion. Those companies who are aware of latest developments tend, by and large, to be the bigger corporations who have more to gain by reducing costs of waste disposal. As costs rise, smaller and smaller companies will attempt to get the information they require to determine what approaches to waste reduction are available and applicable to their particular situation.

The economics of industrial waste reduction are quite complex. Unlike most industrial decisions, the cost of doing nothing is not zero. Very few industrial waste reduction approaches have positive economic benefits when considered in isolation. They become economically attractive when the "negative cost" of the "raw material" (i.e. waste) is considered. This "negative cost" is based on the cost of treatment and disposal of the waste as the alternative approach to its management. Obviously, if wastes can be put into the sewer with no surcharge, or disposed at a municipal landfill site at a very low cost, this "negative cost" incentive will be very low. The imposition of stiff sewer surcharges, and/or the directing of the waste stream to a licensed industrial waste treatment and disposal facility will increase, by an order of magnitude, the financial incentive to examine waste reduction approaches.

It is important for legislators to give a signal to industry as to which waste streams they consider to be of particular concern by legislating those wastes into approved facilities. This will immediately increase the "negative cost" incentive to examine waste reduction opportunities for those streams.

Industry's first responsibility is to its shareholders to run a financially profitable operation. Most industries also strive to be good corporate citizens in protecting man and the environment from any negative consequences of their actions. Industry, however, looks to government for guidance as to what is required to be good corporate citizens. It is, therefore, imperative that government provide strong signals for industry to respond to. If industrial waste reduction is perceived to be desirable, then government should provide strong legislation and enforce that legislation to improve the economics of waste reduction when it is compared to waste treatment and disposal.

OWMC is unique in Canada, being the only crown corporation established for the sole purpose of safely managing industrial wastes. In establishing and operating a waste treatment and disposal facility, it will be assuming the role of an industrial waste management company. Its existence as a Crown Corporation will allow it to consider assuming roles to more positively encourage Waste Reduction. In this chapter of the report, potential roles for OWMC are discussed under two broad headings:

- Implicit Roles
- Explicit Roles.

8.1 IMPLICIT ROLES FOR OWMC

OWMC will implicitly encourage industry to examine waste reduction practices by their very existence, when they become operational. The Province of Ontario has on its books quite stringent regulations governing the handling of industrial and hazardous waste. The Ministry of the Environment have not been able to effectively enforce the legislation without the facilities into which to legislate those wastes. The opening of OWMC's treatment and disposal facilities will enable MOE to assume a much tougher stance on the proper disposition of industrial wastes.

OWMC, through its pricing structure, could then influence the economics of waste reduction, by making the "negative cost" of not applying waste reduction technology sufficiently high to make the waste reduction approach economically attractive.

Looked at simplistically, OWMC could establish very high treatment and disposal fees for those wastes which it feels should be reused or recycled, and lower fees for those wastes which it considers un-reusable. Like most simplistic approaches, it does not stand up when it is scrutinized closely. To be effective, a number of restraints would have to be in place:

- The borders of Ontario would have to be closed to any waste transfer.

- No competing waste treatment and disposal sites would exist within the province.

- Industry would have to have an infinite ability to pay for treatment and disposal or reuse-recycle no matter how high the price.

Obviously none of these restraints are in place, and it is not likely that they ever will be. The selection of a pricing structure for OWMC's treatment and disposal facilities will be based on a very complex assessment of many factors. These include:

- Policy decision on cost recovery, whether to include capital recovery, profit or subsidy

- Policy decision on competitive stance with private waste treatment and disposal facilities

- Decision on what price level may drive industry to find questionable means of disposal

- Policy decision on whether prices are to be determined on a what it costs to process a particular waste, or on an average cost of processing all wastes

- Policy decision on whether to try to discourage industry from disposing of wastes which should be reused.

The issue of pricing to encourage waste reduction becomes even further clouded when the practical operation of the treatment and disposal facility is considered. Two types of wastes which have excellent potential for recycle and reuse are oils and solvents. If a waste treatment and disposal facility has an incinerator for the destruction of organic waste streams, it will need high operating temperatures, to ensure the safe destruction of hazardous organic wastes. If the high calorific value wastes such as solvents or oils are not available, the treatment facility will have to buy fuel to operate its incinerator.

A number of European waste treatment plants have found that they have had to pay for solvent and oil waste streams, to keep their incinerators operating with a minimum of purchased fuel. This is entirely contradictory to the concept of discouraging destruction of waste streams which can be reused, but is considered a practical necessity for running a reasonable cost treatment facility. Other examples of practical constraints are in streams like acids and alkalis. Many acid streams, such as pickling acid, are potentially recyclable. The treatment of acid and alkali wastes in a physical/chemical treatment facility is by neutralization. Ideally, a balance between incoming acid and alkali wastes allows them to be used as mutual neutralizing agents. An imbalance created by recovery of one or the other will result in the treatment facility having to purchase virgin acid or alkali. This, from a global perspective, achieves nothing, as it has just displaced the use of virgin material from the prime industry using recovered material to the treatment plant. The ideal situation in these commodities, therefore, is to see equivalent reductions in the generation of both acid and alkali waste streams.

The use of a specific pricing structure at the treatment facility to encourage waste reduction is not really practical except in the very broadest sense, i.e. the fact that legislation will mandate most industrial liquid and hazardous wastes to proper treatment facilities and will force industry to examine all wastes to see how they can be minimized.

8.2 EXPLICIT ROLES FOR OWMC

A number of explicit roles may be considered by OWMC to promote waste reduction in Ontario. In the sections which follow, the various suggestions which have come from earlier submissions to OWMC and have come from this study are summarized and discussed.

Previous Submission and Recommendations to OWMC

As was discussed in Chapter 1, several submissions and recommendations have been made to OWMC which address the encouragement of reduction as a waste management approach.

The Canadian Manufacturers Associaton(1) (CMA) recommended that the most effective way in which OWMC could encourage waste reduction would be through establishing a sufficiently high price for treatment and disposal to encourage reduction and recycle. This "implicit" role was discussed in Section 8.1. This recommendation is based on the CMA's belief that the major limitations to reuse are the economics of disposal. Philosophically, CMA supports the concept of waste recycle and reuse as being a desirable alternative to treatment and disposal. Their contention that market forces are the only way to encourage reuse and recycle is rather over-simplified. As was discussed in Section 8.1, there are many factors which OWMC will have to consider in establishing prices for waste treatment and disposal. OWMC may not be able to give a strong market signal to industry that it feels a particular waste should be reused. As was cited previously, if OWMC has to pay for waste oils or solvents, to maintain the calorific value of streams fed to its incinerator, this will not give the required "market" indicator that it feels these wastes should be reused.

The CMA is an effective representative of industry's viewpoint. It tends, to some extent, to represent the views of larger companies because its more active members are from those companies. For those larger companies, certainly, the increase in disposal costs would be the most effective method of encouraging reuse and recycle. For smaller companies, who cannot afford to keep engineers or researchers on staff to keep up with the latest developments in waste reduction technology, some of the explicit roles discussed below could also be effective in promoting waste reduction.

Pollution Probe have made a direct submission to OWMC (2) and have made recommendations to OWMC in a press release(3).

In their June, 1981, submission to OWMC(2), Pollution Probe suggested the following 7 activities for OWMC in the field of waste reduction:

1. Allocate significant funds to support waste reduction and recovery.
2. Create a Hazardous Waste Reduction and Recovery Institute.
3. Allocate funds for research into zero waste technologies.
4. Organize a conference on zero waste technologies.
5. Function as a waste broker to find users for waste streams.
6. Study economic and legislative incentives required to encourage waste recovery.
7. Place a surcharge on hazardous waste treatment and disposal to fund zero waste technologies.

In their November, 1981, press release, Pollution Probe updated their previous submission and made 4 recommendations to OWMC(3):

1. Immediately hire several experts in the field of waste reduction and recycling. Establish a waste reduction department within the Crown Corporation.

2. Establish a registry of pollution prevention technology and equipment.

3. Prepare a feasibility study of the pollution prevention potential for each industrial sector.

4. Prepare a 5-year Waste Management Plan for Ontario.

While it is felt that CMA's position that OWMC should not consider any explicit roles to encourage waste reduction is not correct, Probe calls for perhaps too many roles to be practically feasible. The suggestion that OWMC prepare a 5-year Waste Management Plan for Ontario is, perhaps, beyond their purview. This should be the task of the Ministry of the Environment. OWMC should, of course, have their own 5-year plan, and this should include consideration of their role in encouraging waste reduction.

The creation of a Hazardous Waste Reduction and Recovery Institute is not really a proper role for an operating waste management company. This might be more appropriately created at a university, and might be supported by OWMC. Some of the specific tasks discussed under this heading in Probe's submission would be quite appropriate activities for OWMC to be directly involved in, viz:

- Compilation of a registry of zero waste technologies
- Information transfer among businesses
- Compilation of a registry of waste reduction experts
- On-site visits to assist small industry reduce wastes.

The suggestion that a surcharge should be placed on hazardous waste treatment and disposal, to fund zero waste technologies, has been covered previously in discussing pricing policies. The complexity of factors which will influence pricing policy mitigates against this suggestion being practical.

The other suggestions in Probe's two statements are considered in the following sections discussing opinions taken from the industry surveys and from information from jurisdictions outside Ontario.

Results of the Survey of the Primary Metals Industry

The survey of the primary metals industry yielded the least specific opinions on potential roles for OWMC to encourage waste reduction, reuse or recycle. Two extremes of response were encountered. On one extreme were the large integrated steel companies who have departments working on the minimizing of waste production and examining uses for those wastes which are generated. At the other end of the spectrum were the small companies who generate no liquid or hazardous waste.

For the large companies, it was difficult for them to see how OWMC could succeed to solve the problems which several experienced technical groups were already addressing. For the small companies with no wastes, they saw no role for OWMC because they have no problems to be solved.

There was insufficient response to the 8 potential roles, suggested to the participants, for OWMC to encourage waste reduction, to analyze those responses as is done in the following sections reviewing the Fabricated Metals, Chemicals and Recycling industries. Some comments were offered during the survey detailing problems which might be considered by OWMC. These are discussed below.

- Many foundries contacted were extremely concerned about losing the right to dispose of foundry sand in inexpensive landfill sites. Such a move might seriously affect their competitive position internationally. Because of the extremely high volume of this waste, a significant increase in disposal cost would put a very severe economic penalty on this industry. OWMC might consider getting involved in sand reclamation research and even in operating regional sand reclamation centres. This high volume, relatively low hazard waste is the only significant waste from this segment of the primary metals industry.

- The steel industry is composed mainly of three large integrated companies, who have, by and large, done an excellent job in researching and implementing waste reduction opportunities. They found it difficult to see OWMC being able to offer them very much in the way of technical assistance. They do still have several waste streams which they have not been able to find new uses for. These include mill sludges, steel making sludges, and heavy metal contaminated spent sulphuric pickling acid wastes. OWMC could usefully consider the funding of research projects on these wastes.

- In the metal heat treating portion of the primary metals industry, cyanide hardening has been a conventional process. Development of alternative techniques would greatly reduce the hazardous waste from this segment of the industry.

- Several companies indicated an interest in having OWMC technical experts working with them to improve their waste treatment and subsequent disposal practices, to minimize volumes and possibly recover reusable streams.

- Some companies who normally market some of their waste as raw materials for other processes have found difficulties in maintaining those markets during the present period of economic recession. These companies expressed an interest in OWMC stimulating present markets or perhaps more realistically identifying new markets for these wastes or by-products.

- Some companies who have potentially reusable waste streams find that they are located too far from the market for these wastes to be able to economically transfer these wastes. OWMC could consider using their transportation network to subsidize transportion costs for these producers. Regional transfer stations could be used for acceptance and delivery of the reusable waste stream.

- An interest was expressed in an inexpensive analytical service for potentially transferrable wastes and to determine whether wastes can be disposed in a municipal landfill site. This is a role which OWMC might consider for its laboratory. Some caution is required in considering this role. The laboratory could become rapidly overloaded, and there may be quite vocal opposition from the private sector labs who have facilities to serve this market.

- Some of the larger companies contacted identified PCBs that are stored and accumulating as one of the most pressing problems with which they felt OWMC could help them.

Results of the Survey of the Fabricated Metal Parts Industry

The results of the survey of the fabricated metal parts industry with respect to potential roles for OWMC were as follows:

	Response From 68 Interviews		
Suggested Potential Role for OWMC	Positive	Negative	Neutral
1. Trained personnel to visit your plant and advise on waste reduction.	14	4	50
2. Mobile plant for waste reduction visiting your plant once or twice per year.	10	6	52
3. Industry specific seminars on waste reduction.	12	4	52
4. Operating a Waste Exchange program.	6	9	53
5. Operating recycling plants for waste streams not adequately dealt with by private sector.	18	2	48
6. Arguing for improved tax incentives for waste reduction.	15	4	49
7. Arguing for improved legislation to facilitate waste reduction.	12	5	51
8. Conducting or supporting research and development on waste reduction.	18	1	49

The 70 to 80% neutral views expressed by the fabricated metal parts industry are due in large part to the fact that several subsectors of this industry were shown by the survey, not to generate the types of industrial waste which would be of concern to OWMC. A number of the companies surveyed were found to be simple fabricators of metal parts, whose only wastes were scrap metals which are recycled, and regular office waste which is landfilled. The major generators of industrial waste within the fabricated metals industry are those companies involved in electroplating and allied processes.

Examining only the results in which definite positive and negative opinions were expressed, the most positive opinions were held on Roles 5 and 8 -

5. Operating recycling plants for waste streams not adequately dealt with by the private sector.

8. Conducting or supporting research and development on waste reduction.

Many companies who responded on Role 5 felt that they had potentially recyclable materials, which were not being collected by recyclers. Some of these streams are generated in very low volume, or are of poor quality or are an excessive distance from potential recyclers.

There was almost unanimous agreement on the desirability of OWMC conducting or supporting research and development on waste reduction in the fabricated metals industry. Electroplaters are still faced with many problems due to the extremely toxic nature of the materials which they use. All of the hazardous heavy metals, cadmium, zinc, chromium, lead and copper, are daily feedstocks in a plating operation. In addition, these metals are often utilized in the form of their cyanide salts. Thus, both anions and cations used by the platers are potentially environmental hazards. An additional problem faced by the plating industry, included under SIC 34, is that it is, by and large made up of small "jobbing shops" which work on small batches of parts. Thus, sophisticated waste reduction techniques which are applicable to large platers are not appropriate technologies for these small platers. An opportunity, therefore, exists to develop inexpensive, simple technology that can be applied in this industry sector.

The next four potential roles for OWMC for which interest was expressed were, in order of support, Roles 6, 1, 3 and 7 -

6. Arguing for improved tax incentives for waste reduction.
1. Trained personnel to visit plants and advise on waste reduction.
3. Industry specific seminars on waste reduction.
7. Arguing for improved legislation to facilitate waste reduction.

While most companies expressing an opinion were in favour of improved tax incentives to encourage waste reduction, some argued against it on the basis that they would wind up paying for the tax break through other forms of taxation.

With respect to trained personnel visiting the plants, several suggested that these people would have to be very specialized to be of the most benefit to them. There was a split in opinions between larger and smaller companies, smaller companies being more interested in the possibility of help from OWMC to establish waste reduction practices.

While the general opinion was in support of industry specific seminars, the negative opinions expressed were largely that most seminars are too broad-based. This makes it very difficult for operators to pick up information which is sufficiently useful to them in solving the specifics of the problems they encounter in their individual plant situations. These problems are unique in many cases and are not reflected in the hypothetical "typical situations" discussed at seminars.

Opinions volunteered with respect to improving legislation to encourage waste reduction concerned themselves with the need for standardization of municipal, provincial and federal legislation covering the entire area of pollution control.

The only role for which more negative than positive opinions were expressed was that in the area of operating a waste exchange service. Most of those offering opinions were members of the Canadian Waste Materials Exchange (CWME) and felt that this would be a duplication of services. As will be discussed in Section 8.3, there is a definite role for OWMC to enhance the operation of the CWME without duplicating services.

The final potential role, the visit of mobile plant for waste reduction received slightly more positive opinions than negative, but there was some confusion as to how such a service would operate and how it could help the secondary metals industry.

Results of the Survey of the Chemical Industry

The results of the survey of the Chemical Industry with respect to potential roles for OWMC were as follows:

	Suggested Potential Role for OWMC	Response from 69 Interviews		
		Positive	Negative	Neutral
1.	Trained personnel to visit your plant and advise on waste reduction.	10	25	34
2.	Mobile plant for waste reduction visiting your plant once or twice per year	10	26	33
3.	Industry specific seminars on waste reduction	14	21	34
4.	Operating a waste exchange program	12	23	34
5.	Operating recycling plants for waste streams not adequately dealt with by the private sector.	10	25	34
6.	Arguing for improved tax incentives for waste reduction	18	16	35
7.	Arguing for improved legislation to facilitate waste reduction	9	23	37
8.	Conducting or supporting research and development on waste reduction	17	14	38

The proportion of companies interviewed who had a definite view on potential roles for OWMC was much higher for the chemical industry than was the case in both the primary and fabricated metal cases. Approximately 50% had an opinion to offer. The companies who had no strong opinions were, for the most part, those companies who had little or no hazardous or liquid industrial waste.

As was discussed in Section 4.0, the Chemical Industry in Ontario is extremely divergent, ranging from some of the largest corporations in Canada to small packagers of imported bulk chemicals. It covers both these extremes and all ranges of size and complexity in between. The effect of size seems to have been to influence the number of opinions offered. For companies of less than 20 employees, 80% had no opinion on the roles for OWMC. For companies with greater than 20 employees, the proportion of neutral responses ranged from 14 to 36% as follows:

20-50 employees	36%
50-99 employees	14%
more than 100 employees	34%

The pattern for positive and negative opinions between small and large companies was not immediately obvious, except to say that the positive rate for potential Role 8, sponsoring research and development, was largely attributable to the smallest and largest groups of companies; the two intermediate sizes showing more negative opinions than positive. Other responses were similar for all the different company sizes.

Of all the potential roles discussed, only two solicited more positive than negative responses. These were Roles 6 and 8, viz:

- Arguing for improved tax incentives for waste reduction.
- Conducting or supporting research and development on waste reduction.

While the concept of tax incentives was supported, other respondents argued that savings in material, energy or waste disposal costs should be sufficient to encourage waste reduction. This response was generally from companies who had already instituted waste reduction approaches.

The support for research and development as already noted was most marked among large companies (9 to 5 in favour). Specific needs identified were in the field of developing innovative uses for waste streams.

While all other potential roles for OWMC received more negative opinions than positive, there was some enthusiasm expressed for some of these potential roles by some of those who responded positively. These are briefly discussed in descending order of positive opinions recorded.

- **Industry specific seminars on waste reduction**

  This received more support from small companies than large ones. They felt that OWMC sponsored seminars would be cheaper to attend than out of province or international meetings. Larger companies felt that they had access to sufficient information at present through current seminar programs.

- **Operating a waste exchange programme**

  75% of the positive respondents to this role were not aware of the Canadian Waste Materials Exchange Program. This highlights a weakness in the CWME in that it does not have sufficient financial and human resources to ensure that everyone who could benefit from the program is aware of it and how it works.

- **Trained personnel to visit site and advise on waste reduction**

  This was viewed particularly negatively by large companies who felt that they have their own staff experts to advise individual plants on waste reduction technology.

- **Operating recycling plants for waste streams not adequately dealt with by the private sector**

  This potential role found little support and no significant comment from those who did respond positively.

- **Mobile plant for waste reduction visiting plants once or twice per year**

  While this was not widely favoured, some specifics were discussed enthusiastically, e.g. recovery of small volumes of spent solvents for ink manufacturers and reverse osmosis for volume reduction of contaminated aqueous wastes.

- **Arguing for improved legislation to facilitate waste reduction**

  The views generally on this were strongly negative, most respondents saw considerable risk in any increased government participation. An exception to this generally negative response was the need noted for uniform legislation certainly across the province and preferably across Canada. The example of waste reduction being adversely affected by local legislation cited was the Mississauga by-law prohibiting the recovery of fuel values from PCB wastes in a cement kiln.

  Two groups of roles were mentioned when respondents were asked to suggest other useful roles for OWMC. Broadly, these were:

  - To provide an alternative safe waste treatment and disposal facility for all problem waste streams.

  - To provide an information service through a newsletter covering waste reduction technologies and appropriate waste handling and storage procedures.

Roles Identified by the Recycling Industry Survey

The recycling industry is quite different from the primary industries considered in this study, in that they are potentially in a competitive position with OWMC in certain areas. Recycling companies are, by and large, receivers of waste rather than generators. Some do, indeed, produce a residual material from their recovery operations, but this is, in general, a low volume stream. Several of the recyclers are associated with private waste hauling and disposal companies. All are very entrepreneurial in their outlook, and are somewhat skeptical of government becoming involved in an industry which they see as being strictly a private sector operation. Most, however, did acknowledge the need for a safe treatment and disposal facility for those wastes which cannot now be handled. They further accepted that, for public acceptance of such a facility, there was a need for government to become involved. The results of our survey of opinions on useful roles for OWMC should be judged with respect to the background discussed above.

The four roles which were identified as being most useful to the recycling industry were as follows:

- Providing an information service on potential users of recovered materials and on sources of waste streams for recycle in Ontario. This might be in conjunction with the Canadian Waste Materials Exchange.

- Providing a referral service on recycling companies in Ontario who might be able to more effectively deal with an industry's wastes.

- Undertaking or sponsoring research and development in the area of waste recycle.

- Providing an information service to the recycling industry on the latest technical developments in recycling.

Of these four roles, the most important enthusiastic comments were on the referral service and on sponsoring or undertaking research on reuse and recycling technology.

The concept of the referral service would be based on OWMC technical field staff being familiar with the services of the existing recycling industry in Ontario. When these staff members are out reviewing wastes which might be delivered to OWMC for treatment and disposal, they would identify waste streams which could be recycled. The company would then be advised of the existence of all of the recyclers who handle that particular waste. The company would then decide which recycler to contact, and would make their own arrangements for transfer of that waste.

In the area of research and development three specific topics were suggested during the interviews. These were:

1. The recovery of zinc from galvanizers' acid wastes, to render those wastes reusable, and to recover zinc values.

2. Investigate the potential use of sludge from paint wash solvent recovery as a low grade paint product.

3. Investigate the economic recovery of base metals from treated electroplating sludges.

   OWMC could consider either contracting out such work to existing research and development facilities, or utilizing their own laboratory. Utilization of the lab facility at the treatment plant for some research work would, perhaps, tend to balance out the workload. The lab will have to be staffed to give fast turn-around on analyses of incoming wastes, in order that trucks are not tied up at the plant gate for an unacceptable period of time. If the arrival of trucks is sporadic, some ongoing research work could be carried out between arrivals.

The high proportion of positive responses which were received for the two potential information service roles could be described as "non-negative" responses. Everyone agreed that this was a good idea but questioned whether any new information would be available through OWMC which was not now available to the industry through other sources.

All of those interviewed were active participants in the Canadian Waste Materials Exchange (CWME), and so questioned whether OWMC would replace this service. As is discussed later, there is a definite useful role for an organization like OWMC to consider which would be complementary to the CWME.

Two potential roles for OWMC were looked upon very negatively by the recycling industry. These were:

- Installing equipment for the recovery of waste streams not now adequately dealt with by the private sector.

- Bulking of small quantities of wastes and auctioning the bulked materials to the existing recycling industry.

It is hardly surprising that the recycling industry reacted negatively to the first potential role. The general feeling was that, if recovery is not practised now, it is not economical to recover that particular waste. If the economics change, then the private sector will move into recovering that waste stream. The role for OWMC, therefore, would be that discussed in Section 8.1 as its implicit role in influencing the economics of waste recovery through increases in waste treatment and disposal fees.

The negative response to the second potential role in bulking of small quantities of materials was much more surprising. Past experience in talking with recyclers has suggested that there are a lot of sources of material which are too small to be economically collected. The negative response seemed to be based on losing quality control of the recycled stream. The recyclers like to know where the material has been used, and what contaminants are likely to be contained in it. With a bulked composite, they felt that they would not have adequate information on contaminants. This potential role should, perhaps, be reconsidered once the OWMC facility is in place. The objections raised can be countered by a rigorous quality assurance program by OWMC. If they demonstrate that the nature of contaminants in bulked samples can be identified, then it is believed that the recyclers would be interested in recovering these materials.

A more or less neutral response (50% positive, 50% negative) was received to the remaining two suggested potential roles for OWMC. These were:

- Facilitating or providing financing for the development of waste recycling facilities.

- Encouraging government to establish regulatory or tax incentives to encourage the reuse of recycled materials.

By and large the industry's opinion was that financing of waste recycle facilities was not a major difficulty. The companies surveyed raised a point about not wanting to see competitors subsidized by low cost government financing.

The question on encouraging government to establish regulatory or tax incentives to encourage reuse, while only receiving about 50% positive response, was very positively endorsed by a number of companies. This was particularly true of those companies involved in oil recycling. They raised concerns about both ends of their business. They felt that much more stringent controls were needed over the burning of waste oils and over the use of waste oils for dust suppression. It was felt that re-refinable waste lubricating oils, which should have been directed towards the re-refineries, were being used in these applications.

On the marketing of recovered lubricating oils, concern was expressed over the fact that Canada taxed recovered oil products at exactly the same level as new oil. In the United States and Europe, re-refined oils are subject to lower taxes than new oil products. The industry is actively lobbying on its own behalf but felt that support from OWMC would be extremely helpful.

Roles Suggested by Activities in Other Jurisdictions

Activities to encourage waste reduction, reuse and recycle were discussed with respect to two of the most active States in this field in the U.S., viz. New York and California.

In New York State, the body responsible for encouraging waste reduction and recovery is the Environmental Facilities Corporation (EFC). The EFC is a Public Authority, which gives it the same status in the U.S.A. as a Crown Corporation has in Canada.

In California, responsibility for the encouragement of waste reduction is vested in the regulatory authority, viz. the California Department of Health Services. The successful combination of activities in waste reduction and waste regulation is difficult to achieve, and, as noted in Section 7-2 "...it is the legal/regulatory climate in California which permits the exception to the rule".

The various activities of these two organizations are discussed below in terms of how these activities might be appropriate for OWMC to consider.

Waste Exchange

The approach of the two jurisdictions is different. In New York, the EFC has contracted with an existing Waste Exchange, the Northeast Industrial Waste Exchange (NIWE) to help subsidize continuing publication of its quarterly bulletins. The EFC is making use of these catalogues to identify and pursue those waste streams with exchange potential. Articles and supplements are prepared by EFC staff for distribution with the bulletins. This provides the EFC with an outlet to reach industry with ideas it may wish to convey to encourage waste reduction.

In California, the Department of Health Services (DHS) runs its own informational Waste Exchange, with DHS staff working directly with waste producers. It is interesting to note that the waste transfers recorded (see Table 7-4) were all to recyclers. It would appear that the California Waste Exchange does not identify potential direct industrial reusers of waste streams, but concentrates on material handled by the State's recyclers.

Both presently operated waste exchanges are of the "passive" informational type. New York State is presently considering initiating an "active" waste exchange. Conceptually, an E.F.C. staff chemical engineer would actively seek waste transfer opportunities. Potentially reusable wastes would be identified from waybill data, direct contacts would be made with potential users, to try to promote a transfer.

In Ontario, OWMC might consider the combined approach being considered in New York State. The Canadian Waste Materials Exchange is in existence and serves the whole of Canada. This passive information exchange could be supported to provide access to potential waste reusers across the country. OWMC staff in contact with industry could also consider an active role in promoting waste transfers either through the CWME or directly to any known potential users of that waste stream.

Information Activities

The EFC maintains a technical information library for use by staff and individuals or companies interested in waste reduction. They also publish a newsletter "Industrial Materials Recycling Program Status Report".

In California, the DHS is required to maintain a technical reference centre on hazardous waste recycling practices. They are also required to maintain a list of hazardous wastes that are economically and technologically feasible to be recycled. This list, which appeared as Table 7-2, appears to be the only legislated formalized list of its kind in North America.

In Ontario, OWMC has already initiated publication of "The OWMC Exchange". This newsletter could be used to disseminate information on waste reduction and to provide a forum for the exchanging of ideas between government, industry and environmental interest groups. Once OWMC's treatment and disposal facilities are in place, a Waste Reduction Technical Information Library could be established.

The California concept of a legislatively formalized list of wastes which should be recycled does not seem appropriate for OWMC. They should, of course, be interested in what streams are technically and economically recyclable, but to legislate such wastes to recycle is the purview of the Ministry of the Environment of Ontario, if they deem it desirable to do so.

Technical Assistance

The EFC have published "A Preliminary Handbook on the Potential of Recycling or Recovery of Industrial Hazardous Wastes in New York State". A similar study of major industrial waste generators, amounts of wastes capable of being recycled, as well as technology and costs involved to treat these wastes, was undertaken in California.

In New York, consultants are used to address specific issues, identified on an industry-wide or individual company basis by EFC staff. Within limits, direct assistance is provided to industry by EFC staff. Similarly, in California, DHS has carried out plant inspections to educate generators in better methods of waste handling to improve its recyclability.

In California, the DHS has encouraged and promoted the use of innovative technology to render specific waste streams recyclable.

All of the activities described above should be considered as potential roles for OWMC in Ontario. Two sources of technical information on recycling and recovery are: Pollution Probe's "Profit from Pollution Prevention"(5) published in July, 1982; and an Environment Canada study due for publication in mid 1983, which examines Waste Reduction opportunities in the Ontario community of Kitchener-Waterloo.(6) Both these studies have excellent reviews of technology available for the abatement, reduction, reuse and recycle of industrial wastes generated in Ontario.

Serious consideration should be given by OWMC to the qualifications it should require its "technical field staff" to have. Ideally, they should have sufficient background that, when they are discussing a waste stream which industry wants OWMC to treat, they should be able to advise on whether the waste could be reused or recycled, or how the company could render the waste reusable or recyclable.

As an alternative to this all being done in-house, OWMC could consider using outside consultants to review specific opportunities for waste reduction.

The active promotion and possibly the financial support for development of innovative technology to render specific wastes recyclable is another activity which OWMC should be considering.

Notes in Section 7-1 on the New York State program emphasized the need for the protection of confidential information which might be supplied to the Environmental Facilities Corporation. This is a matter which would also have to be carefully addressed by OWMC in planning their activities in Technical Assistance. There is a very delicate balance which must be struck between, legitimate transfer of waste reduction approaches and technology, and disclosure of commercially confidential information.

Other Activity

In California, the DHS is authorized to issue letters of enquiry to generators of hazardous waste who dispose of wastes which are on California's "Wastes which are Recyclable Lists". The generator has to justify why the waste is not being recycled.

This is not felt to be an appropriate activity for OWMC to undertake in Ontario. The Ministry of the Environment may wish to consider reviewing their waybills, and undertake a similar "inquiry project". While rejecting this as a formal activity for OWMC, the Waste Exchange, Technical Assistance and Information roles discussed above are all aimed at achieving the same end.

8.3 DISCUSSION

In Sections 8.0 - 8.2, we have summarized the information on potential roles from previous submissions to OWMC and from the results of the surveys carried out during this study. In this section, we aggregate all of this information and discuss all of the potential roles arising from the previous sections.

A total of 14 potential roles have been identified during this study and each will be discussed in some detail. It has been previously stated(4) that there is a hierachy of approaches to Waste Reduction as follows:

- Waste Abatement viz. the use of non-waste or zero discharge technologies in place of current waste producing technologies.
- Waste Reduction viz. the minimization of volume, and combination of waste streams.
- Waste Reuse viz. the direct reuse of a waste stream as a substitute raw material.
- Waste Recycle viz. the upgrading of a waste stream so that the valuable component of that waste is sufficiently pure to make it reusable.

It has been argued that these approaches to Waste Reduction are listed in descending order of desirability, i.e. Don't produce the waste if you don't have to; if you do, minimize it, then try to reuse it or send it for recycle.

The 14 potential roles for OWMC to consider to encourage waste reduction in Ontario are shown in Table 8-1 listed under these four approaches to waste reduction. Some roles are applicable to all four approaches. Others are specific to one, two or three of the four. The numbers in the table refer to the section numbers which follow, discussing each potential role. Table 8-2 lists these roles in terms of their potential timing for implementation.

1. Implicit Pricing Structure

As was discussed previously, this is extremely complex, and the simplistic approach of pricing reusable/recyclable waste streams at an extremely high level is not realistic. The existence of the OWMC facilities, which will give The Ministry of the Environment the opportunity to strongly enforce waste disposal regulations, will greatly increase the general cost level for waste disposal for those wastes now going to municipal landfills and sewage treatment plants. This will, in itself, encourage companies to examine waste reduction opportunities. This, as was suggested by the Canadian Manufacturers Association, may well be the most effective stimulus to industry to examine waste abatement, reduction, reuse and recycle. A ten to twenty-fold increase in the "negative cost incentive" for treatment and disposal is likely to be a most effective stimulus to innovation.

Timing: Work on establishing pricing policies should be beginning almost immediately. This obviously involves much more than a consideration of stimulus to waste reduction, but it is one important parameter to be considered in the overall assessment of pricing policies.

Reassessment will be an ongoing task, and more specific policies to encourage reduction of a specific waste stream will be much easier to consider after a few years of operation and testing of initial pricing policies.

Cost Factor: The costs of this role could be quite high. For example, if all waste oils and solvents were not available to OWMC because a pricing structure discouraging this disposal was successfully directing them to recycle, OWMC may have to buy fuel oil to run its incineration facilities. On the other hand, OWMC might examine the feasiblity of using other waste fuels such as refuse derived fuel, (RDF) or heavy petroleum refinery by-products to supply much of the energy which it requires.

2. Conducting or Supporting Research and Development

This was the most universally supported potential role for OWMC from the surveys carried out during the study. It is applicable to all four approaches to waste reduction, i.e. abatement, reduction, reuse and recycle. Realistically, OWMC's involvement is most likely to be, initially, in the areas of reduction, reuse and recycle. Involvement in the development of low waste or zero waste technologies is likely to be restricted to financial support for specific industry developments.

Several specific areas for research and development were identified during the surveys. These included:

- Developing reuse recycle opportunities for oily mill scales and sludges.
- Developing uses or recovery technology for sulphuric pickling acids heavily contaminated with metals other than iron. (e.g. zinc)
- Investigating the practicality of alternatives to cyanide heat treating.
- Feasibility study on the application of foundry sand reclamation technology.
- Developing recovery technologies for steel plant chromium contaminated waste waters.
- Developing innovative uses for waste streams from the chemical industry.
- Developing a process to recover zinc from galvanizers' acid waste.
- Researching the possible use of sludge from paint solvent recovery as a low grade paint product.

- Researching the possibility of economically recovering base metals from treated electroplating sludges.

The range of involvement which OWMC might consider for this potential role would be all the way from actually conducting research and development projects in its own laboratory facility, to acting as a supporter for companies seeking research and development financing from government or other institutions. Between these two extremes would be the contracting out of research and development projects to existing institutions and cost sharing arrangements with industry on projects.

OWMC would be in a unique position to judge, in conjunction with its industrial customers, research and development needs in this area. It would be important to ensure that development programs really addressed the problem as it exists in terms of production constraints, scale, etc. These "hands on" constraints are sometimes ignored when research and development is conducted without close interaction with the industry whose problem is being addressed.

OWMC should work with The Ontario Ministry of the Environment and with Environment Canada to establish priorities for research and development needs in waste reduction, and to develop long term funding arrangements, taking advantage of existing programmes such as Environment Canada's DRECT. It should also work with the existing research communities to take advantage of the human resources which are available to tackle problems as they are identified by OWMC. Industry associations would be another group who could play a useful role in assessing research and development needs in their particular industry sectors.

Timing: Work to establish contacts with MOE and Environment Canada could begin as soon as is convenient. Contact with industry associations and the research community similarly could be undertaken prior to OWMC's facilities being opened. Obviously, any work to be undertaken by OWMC's own laboratory would have to wait until the facilities had been established for a year or so before it would have the time to tackle research and development. Sponsoring research and development in industry or the research community could begin immediately if funds are available.

Cost Factors: Research and development is generally expensive, and gives no guarantees of success every time a project is undertaken. This is a very important area to consider for scarce research dollars. OWMC funds available to promote research and development into waste reduction can be leveraged upwards by taking advantage of Federal and Provincial funding programs, and by going into cost sharing projects with individual companies or industry associations. Some more basic research projects might be considered for appropriate university departments, e.g. The Institute for Environmental Studies at the University of Toronto.

3. Information Services

The concept of OWMC undertaking an information dissemination role was received with a mixture of enthusiasm and skepticism. The larger companies did not feel that OWMC could present information that was not already well known to their in-house experts. The smaller companies, however, did indicate that they would be interested in some help in keeping up to date on the latest developments in waste reduction for their particular wastes.

Information dissemination could take many forms. Two which might be considered are:

- Publication of industry by industry handbooks on the potential for waste abatement, reduction and reuse.

- Publication of a regular newsletter containing reports on ongoing research work, new approaches to waste reduction, etc.

Some of the industry by industry handbooks could be prepared from information in this report, from Pollution Probe's "Profit from Pollution Prevention"(5) and from the upcoming Environment Canada report on "Waste Reduction in the Region of Kitchener-Waterloo"(6).

The newsletter could be an expansion of the "OWMC Exchange" to include summaries of developments, and indicating a contact person for further information. The newsletter could be used as it is in the New York State program, as a forum for the exchange of technical information between industry, government, trade associations and public and environmental interest groups.

Information dissemination is appropriate for all four approaches to waste reduction, particularly the first three, abatement, reduction and reuse.

Timing: Since OWMC is already publishing "The Exchange", dissemination of information on waste abatement, reduction and reuse could begin almost immediately. Potential contributers should be invited to prepare short relevant articles. The preparation of handbooks should perhaps wait until OWMC facilities are in place.

Cost Factors: The expansion of The Exchange newsletter will involve some additional costs, particularly if the circulation list is expanded, but it is unlikely that the costs would exceed $30-$50,000 per year. The costs for the preparation of Industry Handbooks would be somewhat higher than this and care should be taken in considering how these can be kept up to date on an ongoing basis, and whether, in fact, their utility will justify the costs involved.

4. Technical Field Staff Visits

It is anticipated that OWMC will have technical field staff as soon as their facilities are established. The main job of these people will be to assess the waste streams for their treatability at an OWMC facility. This technical field staff, if properly trained, would be in an ideal position to assess opportunities for waste abatement, reduction, reuse and recycle, in companies throughout Ontario.

Their role would be to endeavour to point out to the company, where, for example, wastes are being mixed rendering them unusable, what opportunities are available for waste reuse, and what companies in Ontario would take recyclable wastes for recycle. They might also refer companies to the Canadian Waste Materials Exchange. Care would have to be taken not to favour one recycler over another, and over the transfer of confidential information. This might be a greater problem in the case of waste abatement. It would not be proper to report to a company that its competitor down the street has just installed a new zero waste process.

Notwithstanding these potential problems, the technical field staff would be a most important part of OWMC's program to encourage waste reduction. They would be the front line troops assessing problems which might then be the subject of an research and development programme, or suggesting where a more detailed assessment of the problem might be undertaken in a follow-up expert's site visit. They are also potentially the most effective communicators of information developed by OWMC.

Quite good support for this potential role was gathered from the surveys of industry in this study.

Timing: Realistically, they cannot be effectively employed until OWMC waste treatment facilities are established. They should definitely be hired before opening day so that they can undergo some training.

Cost Factors: The attractive feature of this approach to realize waste reduction opportunities is that it can be done with only marginally increased costs over an operating expense which would be incurred anyhow. In order to attract the qualified people to this job, a salary premium would have to be offered over that which would be required for non-technical field staff. Graduate chemists or chemical engineers or "engineers by experience", preferably with many years of industrial background, would be ideal candidates for these positions.

5. Arguing for Improved Tax Incentives and Legislation to Encourage Waste Reduction

The responses during the survey to both these potential roles ranged from great enthusiasm to hostile rejection. The negative opinions were directed in the main to increased government legislation in a field like waste reduction. Most industry people believe that Government should legislate what can and cannot be discharged to the environment, air, water, and land, but then they feel that economic forces should dictate whether waste reduction is undertaken. The concept of government making industry justify not recycling, as is being done in California, did not gain any widespread industry support.

While OWMC cannot and should not assume any legislative role they may in practice achieve the same ends as that being achieved in California. The technical field staff will in fact be encouraging companies to investigate reduction reuse and recycling opportunities for potentially recyclable wastes.

The use of tax incentives to encourage waste reduction through improving its economic feasibility, on the other hand, was felt to be a useful government activity. Support for the concept of OWMC lobbying for such tax incentives was evident during the industry surveys. Specifically, tax reductions for re-refined oil products were mentioned by all the companies in the oil recovery business.

Timing: This could be a useful ongoing role for OWMC.

Cost Factors: This should incur minimum out of pocket expenses. It will be part of the ongoing dialogue between OWMC, Industry, Industry Associations, and the various levels of Government. This is an activity in which the board members of OWMC should consider being involved.

6. **Library Facilities**

OWMC already maintains a library for its own use. The dedication of a part of that library to information on waste abatement, reduction, reuse and recycle would be a logical extension to this facility. Allowing others to use the library facility would again be another logical extension. This would involve the establishment of some administration procedures to control the use of the facility. It would be difficult to extend borrowing privileges to outside users, so the library would essentially be like the reference section of any library. Financially self-supporting copying facilities would allow users to take away those sections of reports, etc., which are of interest. Similarly, a link to data retrieval systems might be considered both for OWMC use and for other users of the library. User charges should be considered for outside users.

Timing: This might be more logically considered when a site for OWMC facilities is established.

Cost Factors: Additional out of pocket expenses, such as copying and data searching, should be covered by user fees. Some minor additional administrative cost would probably be incurred.

7. **Industry Specific Seminars**

OWMC's potential role in sponsoring industry specific seminars on waste reduction opportunities was more positively viewed by smaller companies than by larger ones. Even those seeing this role as a valuable one gave somewhat conditional positive responses. Their concern was that the seminars should be specific to their particular problems, and not generalized to the extent of not being relevant. Many individuals in small companies wear more than one hat; waste reduction is only one of their many concerns. They do not need a meeting with a lot of "academic giants" of the waste reduction field pontificating about their latest research results. They want to know "what the heck they can do to avoid producing those two barrels of crud a day that's costing them two bucks a gallon for disposal".

OWMC's technical field staff should be able to define the problems of concern to particular industry sectors. Industry associations should also be in a position to help outline the real concerns of their industry. They, together with OWMC, should be able to come up with a useful seminar format. In many cases, a "workshop format" might be better than a straight seminar; establishing a dialogue with participants rather than just lecturing to them.

Possible topics for initial seminars might include:

- Foundry Sand Reclamation
- Recovery of Values from Heavy Metal Contaminated Acids
- In-plant Solvent Recovery Systems.

Timing: This activity could be considered immediately if OWMC has sufficient resources to undertake such activities, considering all of the other work involved in establishing treatment and disposal facilities. It should be considered as an ongoing role, addressing problem areas as they are identified.

Cost Factors: Some OWMC staff time would be involved in this activity. Out of pocket expenses could be covered by charging a modest registration fee.

8. Expert Site Evaluation

This potential role for OWMC would be an extension of the initial waste reduction opportunities assessment made by the technical field staff. In some medium sized companies, particularly those with older plants, the flows of wastes within the plant are difficult to define. Until such a definition is made through a waste survey, it is difficult to determine what opportunities exist for waste abatement, reduction or reuse. OWMC could consider having such a site evaluation made.

The selection of sites to be evaluated would have to be carefully made. The question could be raised - 'Why should OWMC finance a company's waste survey and evaluation of waste reduction opportunities?' A legitimate reason would be that OWMC believes that there are opportunities for waste reduction in this particular industrial sector, and this is being undertaken as a demonstration. Such a demonstration project has to be at an actual Ontario plant. Identifying hypothetical waste reduction opportunities is of very little benefit to anyone. To be meaningful, they must relate to a specific industrial situation. Such expert evaluations would probably be best done by consultants specializing in the various industry sectors, with funding being provided by OWMC. The workload for this activity and the variable background required would suggest that contracting out would be preferable to the undertaking of the work by OWMC staff.

Timing: This activity cannot be realistically considered until OWMC's technical field staff have been hired.

Cost Factors: This activity does not involve any specific commitment of funds which is implied if staff are hired full time. Ontario Research Foundation experience in this area suggests that costs for such evaluations would be in the $5,000 to 50,000 range.

9. Waste Exchange

The role of OWMC in waste exchange was viewed with some confusion by many of the companies surveyed. The confusion particularly arose among companies who were already participating in the Canadian Waste Materials Exchange (CWME) program, who wondered if OWMC would not be duplicating this service.

While the CWME is a relatively successful national passive information exchange, there are definite areas which could be improved to increase its effectiveness. One of its major shortcomings is that it does not have "active feet on the ground" identifying waste streams which have potential for reuse or recycle. This is not feasible with its present funding level which supports 0.5 man years per year. There are still many companies who are not aware of its existence or how it can help them try to find users for their waste streams. Another problem faced by CWME is that it does not have a guaranteed source of funding. Roughly one-third of its funding comes from industrial participants, the remainder coming from grants from the Federal and some Provincial governments.

OWMC's technical field staff could enhance the operation of CWME by being a proponent of the service to industries visited who have potentially reusable wastes. CWME in its turn extends the OWMC's search for potential reusers of listed wastes or suppliers of wanted wastes beyond the boundaries of Ontario to the whole of Canada.

Ideally, to make the Canadian Waste Materials Exchange program more effective, a similar activity to that suggested for OWMC should be taking place in all the various regions of Canada; local groups working to promote local exchanges but using the services of the National Exchange to increase the chances of finding waste transfer opportunities.

Timing: Since this activity would be dependent on the technical field staff being available, this activity could not begin effectively until they have been hired.

Cost Factors: Costs associated with the extra time required by the technical field staff would be the major financial consideration of this activity. Consideration also might be given to financially supporting the CWME to ensure its continued viability.

10. **Analytical Services**

The need for inexpensive reliable analytical services was identified by some companies in the survey of the primary metals industry, particularly with respect to potentially reusable or recyclable waste streams. This information may be available as a by-product of analyzing a waste which would be potentially delivered to OWMC's treatment and disposal facilities. To set up to offer analytical services which are offered by the private sector testing laboratories would, most likely, result in some justifiable protests.

The development of analytical test methods, if these are not available, or identifying potentially reusable wastes as a result of screening of wastes for acceptance at OWMC treatment facilities, would be proper potential roles for OWMC to consider.

Timing: After OWMC facilities are open and operating.

Cost Factors: There would be very little incremental costs over the costs of operating the facilities' laboratory.

11. **Operation of Mobile Plant**

The role of mobile plants would be in the areas of waste reduction and possibly in waste recycle. In the former case, processes such as filtration, membrane separation, or ion exchange could be taken to plants whose volume of waste would not justify the capital cost of installing such a plant. These volume reduction processes would be applied to stored aqueous wastes, separating them into a small volume of concentrated waste which would be delivered to OWMC's treatment facility, and a large volume of wastewater which would be discharged to sewer. In the ideal situation, the low volume concentrated waste would be suitable for reuse or recycle.

A mobile plant is being operated by the private sector for oil recycle. Contaminated specialty oils are stored,and the oil recoverer brings in his mobile recovery facility, cleans the oil and returns it to the process from which it came. Some interest was expressed in the industry survey in a similar service for small quantities of solvents.

The need for OWMC to become involved in the operation of mobile plants is more likely to be apparent after a few years of operation of their treatment and disposal facilities. Certainly the West German waste treatment and disposal firm, WESTAB, have become very involved in the operation of mobile waste reduction equipment(7).

Timing: The need for this potential role should be assessed after a few years of operating experience of treatment and disposal facilities.

Cost Factors: This operation should be self-supporting through user fees.

12. Transportation of Reusable Materials

This potential role was suggested during the industry survey. It had not been considered prior to this. The concept would be to take advantage of OWMC's transportation network to make the reuse of reusable materials from remote locations economically viable. It is an interesting idea. It would involve OWMC transfer stations accepting reusable or recyclable materials and shipping them, if possible using empty space on a truck or train, to the central treatment and disposal facility. The wastes could be picked up by the reuser or recycler from OWMC's treatment facility, which, it is assumed, would be closer to those reusers.

Timing: This potential role is obviously unfeasible until OWMC's full network of facilities is in place.

Cost Factors: Some additional transportation costs would be incurred. These would be minimized if reusable materials are used to fill up loads, where this is technically safe and feasible.

13. Bulking of Small Quantities of Wastes for Recycle

This potential role for OWMC drew very mixed responses. The consensus in the recycling industry was that they did not see this as a useful role for OWMC. Their major objection seemed to be that they liked to know where the wastes had come from in order to be able to know what kind of contaminants they might expect. While the question of bulking of small quantities of wastes was not put to the three primary industry sectors surveyed, several respondents volunteered an opinion on the need for such a service. It was indicated that the recyclers are not always willing to accept small volumes of wastes such as solvents for recycle.

The concerns of the recycling industry can be addressed if OWMC puts in place a quality assurance programme for its bulking activities. Discussions with the recyclers would reveal the contaminants of major concern and an analytical programme could be developed to check for these contaminants in the bulked material.

Timing: This role is not practical to consider until OWMC facilities are in place.

Cost Factors: This role should not incur major costs. The bulked materials could be sold to try to cover costs of the collection, storage and quality assurance.

14. **Operation of Recycling Processes**

This potential role, for OWMC to become active in the recycling business, drew very negative comments during the survey of the recycling industry. The general opinion was that, if it is economically viable to recycle a waste, the private sector will establish the facilities required to recycle that waste. They saw the OWMC's role to establish cost structures for waste treatment and disposal at such a level to make recycle of that waste economically viable. This expressed opinion reflects the very private-sector oriented nature of the recycling industry.

While no immediate need for OWMC to consider establishing recycling facilities was identified during the industry surveys, this possibility should not be totally rejected. OWMC may decide that a recovery facility, while not being economic on a stand-alone basis, would facilitate subsequent treatment of the remainder of the waste from which a value had been recovered.

The whole question of OWMC's policies with respect to competing with the private sector is quite complex and beyond the scope of the present study. Once such a policy has been established, the role of OWMC in the operation of recycling facilities should be re-examined.

Timing: This is a role to be considered when facilities are operating.

Cost Factors: Operation of such facilities should break even or even show some benefit in the overall cost of treatment.

TABLE 8.1
SUMMARY OF POTENTIAL ROLES FOR OWMC TO ENCOURAGE WASTE REDUCTION

WASTE ABATEMENT

1. Implicit Pricing Structure
2. Research and Development
3. Information Services
4. Technical Field Staff Visits
5. Tax and Legislation
6. Library Facility
7. Industry Specific Seminars
8. Expert Site Evaluations

WASTE REDUCTION

1. Implicit Pricing Structure
2. Research and Development
3. Information Services
4. Technical Field Staff Visits
5. Tax and Legislation
6. Library Facilities
7. Industry Specific Seminars
8. Expert Site Evaluations
11. Mobile Plant Visits

WASTE REUSE

1. Implicit Pricing Structure
2. Research and Development
3. Information Services
4. Technical Field Staff Visits
5. Tax and Legislation
6. Library Facilities

WASTE REUSE (contined)

7. Industry Specific Seminars
8. Expert Site Evaluations
9. Waste Exchange
10. Analytical Services
12. Transportation for Reusable Materials

WASTE RECYCLE

1. Implicit Pricing Structure
2. Research and Development
3. Information Services
4. Technical Field Staff Visits
5. Tax and Legislation
9. Waste Exchange
10. Analytical Services
11. Mobile Plant
12. Transportation for Reusable Materials
13. Bulking of Small Quantities
14. Operating Recycling Processes

TABLE 8.2

POTENTIAL TIMING FOR IMPLEMENTATION OF ROLES

1. PRIOR TO FACILITIES BEING ESTABLISHED

1. Implicit Pricing Structure
2. Research and Development
3. Information Services
5. Tax and Legislation
7. Industry Specific Seminars

2. DURING CONSTRUCTION OR IMMEDIATELY FOLLOWING OPENING OF FACILITIES

4. Technical Field Staff Visits
9. Waste Exchange

3. AFTER FACILITIES HAVE BEEN ESTABLISHED

6. Library Facility
8. Expert Site Evaluations
10. Analytical Services
11. Mobile Plant
12. Transportation of Reusable Materials
13. Bulking of Small Quantities of Recyclable Materials
14. Operating Recycling Processes

8.4 REFERENCES

1. The Canadian Manufacturers' Association Submission to OWMC on "Phase 1 Report and Recommendations", October 21, 1982.

2. Pollution Probe "Recommendations to the Ontario Waste Management Corporation w.r.t Hazardous Waste Reduction and Recovery", June, 1981.

3. Pollution Probe. Press Release "Potential for Waste Cutbacks Is Enormous", Queen's Park, November 27, 1981.

4. Proctor & Redfern Limited, Weston Designers-Consultants, and Ontario Research Foundation (1982), "Waste Reduction Background Paper", prepared for Ontario Waste Management Corportion.

5. Campbell, M., and Glenn, W.M. "Profit from Pollution Prevention" a guide to industrial waste reduction and recycling. Published by the Pollution Probe Foundation, Toronto, July, 1982.

6. Environment Canada, Study in Progress, "Industrial Waste Prevention: An Assessment, and Demonstration Program in the Region of Waterloo". Report to be published mid-1983.

7. Proctor & Redfern Limited, Weston Designers-Consultants, and Ontario Research Foundation (1982) European Tour. Report prepared for Ontario Waste Management Corp., Toronto, Ontario.

9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSIONS

1. That the three Ontario industry sectors surveyed are already making some efforts at waste abatement, reduction, reuse and recycle.

2. That, in the main, larger companies are better able to adopt such practices because of some or all of the following:

   - In-house expertise on the best approaches available

   - Larger waste streams making economic recovery, reuse or recycle more feasible

   - A greater economic penalty because of the much larger waste volumes, if treatment and disposal are chosen.

3. That the major reason for companies adopting waste abatement, reduction, reuse and recycle, is the "negative cost incentive" resulting from proper treatment and disposal prices.

4. That the trends expected in waste quantities remaining for treatment and disposal will be downward over the next few years. (This conclusion was difficult to quantify, particularly as the study was carried out at a time when the three industry sectors were very adversely affected by the prevailing economic recession. At the time of the study, everyone reported lower waste generation than normal. They were asked to assess trends almost on a per unit of output basis resulting from adopting waste reduction practices).

5. That a well established recycling industry exists in Ontario, particularly for:

   - Solvents
   - Waste oils
   - Oily water
   - Pickling acid.

6. That some smaller to medium sized companies who do have waste problems would welcome some help from an organization such as OWMC to establish procedures to abate, reduce, reuse or recycle those wastes.

7. That there are 14 specific potential roles for OWMC to consider to help industry realize reduction opportunities.

8. That the awareness of OWMC's existence and purpose is quite low amongst the companies from the 3 industry sectors surveyed. This is particularly so for smaller and medium sized companies.

9.2 RECOMMENDATIONS

1. That OWMC consider potential for abatement, reduction, reuse and recycle, as a factor in establishing pricing policy for a particular type of waste. While making this recommendation, it is recognized that there are many practical constraints which are discussed in Chapter 8. Further, it must be recognized that this is only one factor in the very complex process of establishing pricing policies.

2. That OWMC give serious consideration to adopting the remaining 13 "explicit" potential roles outlined in Chapter 8, to encourage waste abatement, reduction, reuse and recycle.

3. That OWMC concentrate its consideration of those potential roles initially on the following 6 which could be implemented prior to facilities being established or immediately following their opening:

   - Support of research and development in the field of waste abatement, reduction, reuse and recycle.

     Co-ordination of this effort with The Ontario Ministry of the Environment, Environment Canada and Industry Associations is recommended.

   - Dissemination of information on waste abatement, reduction, reuse and recycle.

     Expansion of "The Exchange" would allow this activity to begin very rapidly with a minimum of additional cost.

   - Technical field staff visits.

     A competent technical field staff is key to a number of the potential roles to encourage waste reduction. Consideration should be given as soon as possible to the size and qualifications for this group. They would be heavily relied upon to identify opportunities for abatement, reduction, reuse and recycle within industry, and they should be trained to be able to offer advice, or recommend further study.

- Industry specific seminars on waste abatement, reduction and reuse approaches.

  A need for very specific industry seminars was identified. It was stressed that these should be narrow in focus to be as useful as possible in addressing specific problem areas.

- Waste Exchange

  A number of ways of OWMC enhancing the potential of the Canadian Waste Materials Exchange program are discussed in Chapter 8.

- Tax incentives and legislation to encourage waste abatement, reduction, reuse and recycle.

  Efforts to increase waste reduction through tax incentives or legislation should be undertaken in consultation with industry associations. Industry opinions expressed during the survey were positive toward tax incentives but rather negative toward direct legislation of waste reduction. Indirect legislation on environmental protection which would result in favourable economics for waste reduction was more acceptable to the companies surveyed.

4. That OWMC undertake efforts to increase the awareness of its existence and purpose to industry in the province; particularly among the small to medium sized manufacturers who could perhaps most benefit from OWMC's help in establishing waste reduction practices.

APPENDIX A

PACKAGE SENT TO COMPANIES TO BE INTERVIEWED

Dear Sir:

The Ontario Waste Management Corporation is a Provincial crown agency responsible for developing a province wide system to ensure the safe management of industrial waste. As part of this responsibility, OWMC will be developing programs to assist industry in the reduction and recycle of wastes wherever this is technically and economically feasible. We consider that waste reduction is an important part of the safe management of our industrial waste.

To assist in the planning of our role in waste reduction, reuse and recycle, we have retained the firms of Ontario Research Foundation, Proctor and Redfern, and Weston Designers/Consultants, who will undertake a survey of industrial waste reduction practices in three key industry sectors in Ontario. The objectives of the survey are:

1. To determine trends in waste quantities and composition resulting from waste reduction practices implemented by Ontario Industry.

2. To establish roles which OWMC might consider undertaking to encourage waste reduction in Ontario.

We need your help to achieve these two objectives. A representative of Ontario Research or Proctor and Redfern will be telephoning you within the next few weeks to run through a series of questions which are basically outlined in the attached questionnaire. We anticipate that this will only take 15 - 20 minutes of your time. All of the information which you supply us will be held in the strictest confidence.

Your co-operation at this time will be of tremendous help to us on two counts. Firstly, we will be able to plan more effectively our treatment facilities for the residues of waste reduction practices. Secondly, we will be able to identify appropriate roles of OWMC in assisting industries to reduce or recycle waste streams.

Yours very truly,

ONTARIO WASTE MANAGEMENT CORPORATION WASTE REDUCTION STUDY

Questions on Waste Reduction and Recycling which will be discussed in the telephone interview.

1. What types and quantities of industrial liquid, sludges and hazardous solid wastes are generated at your plant? Please include any which are reused or recycled.

2. What trends in quantities do you anticipate because of:

   (a) an upturn in the economy, or
   (b) change in your processes?

3. Have you undertaken any process modifications to eliminate or reduce the amount of wastes which you produce? Include any housekeeping practices introduced to minimize waste quantity.

4. Are you presently examining waste reduction possibilities and do you have any future plans to institute waste reduction practices? If not, what are the major barriers making waste reduction unattractive?

5. Do you have any wastes which are being reused as raw materials within your own plant or by others, and what are they used for?

6. Do you have waste streams which could be reused by yourselves or others, but are not presently reused?

7. What do you consider the major barriers to the reuse of these wastes?

8. Have you listed any of your waste streams on the Canadian Waste Materials Exchange? If so, have any potential users for your wastes been identified? Are you, in fact, aware of the existence of the Canadian Waste Materials Exchange?

9. Do any of your wastes go to companies specializing in the recycle of waste materials, e.g. solvent refiners, oil rerefiners?

11. Do you consider that your activities in waste abatement, reduction and reuse are typical for your industry sector in Ontario?

12. Ontario Waste Management Corporation's mandate covers all aspects of waste management. They are publicly committed to encourage waste reduction, reuse and recycle. What activities do you feel that OWMC could undertake to help you to reduce or reuse some of your waste streams? A few examples of potential activities which we would like to discuss include the following:

    - Trained personnel to visit your plant and advise on waste reduction.
    - Mobile plant for waste reduction which could visit your plant once or twice per year, e.g. neutralization, dewatering, filters, reverse osmosis units.
    - Industry specific seminars on waste reduction.
    - Operating a waste exchange program for waste reuse.
    - Operating recycling plants for waste streams not adequately dealt with by the private sector.
    - Arguing for improved tax incentives for waste reduction.
    - Arguing for improved legislation to facilitate waste reduction and reuse.
    - Conducting or supporting research and development on waste reduction.

    This is not an all inclusive list. Your specific input to this question will greatly enhance OWMC's ability to establish useful roles for itself in this area.

A - 5

COPY OF THE OWMC EXCHANGE

INDUSTRY SURVEY QUESTIONNAIRE

Plant Code Number ______________________

Company Name ______________________

Location ______________________

Telephone Number ______________________

Contact ______________________

ONTARIO WASTE MANAGEMENT CORPORATION WASTE REDUCTION STUDY
INDUSTRY INTERVIEWS

Plant Code__________ No. of Employees__________ SIC No.(s)__________

Products____

(Types and quantities of wastes generated reduced, reused and recycled are recorded on the following pages(s).)

Do you consider that your activities in waste abatement, reduction and reuse are typical for your industry sector in Ontario?

☐ Yes ☐ No

They are publicly committed to encourage waste reduction, reuse and recycle. What activities do you feel that OWMC could undertake to help you to reduce or reuse some of your waste streams? A few examples of potential activities which we would like to discuss include the following:

	Yes	No
- Trained personnel to visit your plant and advise on waste reduction.	☐	☐
- Mobile plant for waste reduction which could visit your plant once or twice per year, e.g. neutralization, dewatering, filters, reverse osmosis units.	☐	☐
- Industry specific seminars on waste reduction.	☐	☐
- Operating a waste exchange programme for waste reuse.	☐	☐
- Operating recycling plants for waste streams not adequately dealt with by the private sector.	☐	☐
- Arguing for improved tax incentives for waste reduction.	☐	☐
- Arguing for improved legislation to facilitate waste reduction and reuse.	☐	☐
- Conducting or supporting Research and Development on waste reduction.	☐	☐

This is not an all inclusive list. Your specific input to this question will greatly enhance OWMC's ability to establish useful roles for itself in this area.

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Plant Code ________ Page __ of __

	Waste No.
Waste Generation	Type
	Phase
	Quantity
	Frequency
	Container
	Current fate
	Future
Waste Reduction	
	Barriers to waste reduction
Waste Reuse	Current recovery this plant
	Current recovery other plants
	Future recovery opportunity
	Barriers to reuse
Waste Recycling by Contractors	Waste currently recycled
	Which recycle contractor
	Barriers to recycle
	Have you listed waste with OWMC?

Notes

QUESTIONNAIRE FOR SURVEY OF THE ONTARIO RECYCLING INDUSTRY

COMPANY CODE NUMBER ______________________________

COMPANY NAME ______________________________

COMPANY LOCATION ______________________________

TELEPHONE NUMBER ______________________________

CONTACT ______________________________

QUESTIONNAIRE ONTARIO RECYCLING INDUSTRY

COMPANY CODE__________

Section 1 - General

1.1 How would you describe your role in the recycling industry?

(a) Broker charging a fee but not taking possession of the waste.

(b) Broker taking legal but not physical possession of the waste.

(c) Broker taking both legal and physical possession of the waste.

(d) Reclaimer having processing facilities to upgrade waste qualities.

1.2 Approximately how many employees do you have?

1	-	5	☐
5	-	20	☐
20	-	50	☐
50	-	100	☐
100			☐

1.3 In what year was your company established? ______

1.4 What geographic areas do you serve in Ontario.

____

____

1.5 What types of waste materials do you handle?

(a) ______________________________

(b) ______________________________

(c) ______________________________

(d) ______________________________

(e) ______________________________

(f) ______________________________

(g) ______________________________

(h) ______________________________

(i) ______________________________

Section 2 - Waste Quantities

Waste Material ____

2.1 Approximately how much of this material do you handle/year? __________

2.2 Is the amount of this material which you handle,

Increasing ☐ or

Do you think this is because:

- Its production is increasing ☐
- The cost of disposal is increasing ☐
- The cost of raw material is increasing ☐
- Aggressive marketing by you ☐
- You are able to give more favourable economic terms ☐
- Industry is more aware of recycling ☐
- Government action to stimulate recycling ☐
- Increased markets for recovered material ☐

Decreasing ☐

- Its production is decreasing ☐
- Industry is reusing it in-house ☐
- It's cheaper to dispose of it ☐
- Decrease in your market share, industry-wide trend being stable or upward ☐
- Government action/inaction is responsible ☐
- Industry is not aware of uses for this material ☐
- Decreased market for recovered materials ☐

2.3 What are the major barriers for further reuse or recycle of this material.

Additional sources are too highly contaminated ☐

Additional sources are too small to be economical ☐

Additional sources are too far away to be economical ☐

This is only a limited market for recovered material ☐

Capital costs for increased capacity in reclamation plant too high ☐

Government legislation makes increasing capacity difficult ☐

2.4 (For reclaimers) What is the nature of any residuals from your plant reprocessing this material?

Quantity approximately per year ____________

Nature:	solid	☐	Packaging:	bulk solid	☐
	sludge	☐		bulk liquid	☐
	liquid	☐		drums	☐
				bags	☐

2.5 Trends in quantities of residuals: Increasing ☐ Decreasing ☐

2.6 Trends in qualities of residuals: Less dilute ☐ More dilute ☐

Less viscous ☐ More viscous ☐

Section 3 - Potential Roles for OWMC to Increase Waste Reduction Reuse and Recycle

3.1 Providing a referral service on recycling companies in Ontario who might be able to deal with an industry's waste. ☐ ☐

3.2 Facilitating or providing financing for the development of waste recycling facilities. ☐ ☐

3.3 Encouraging government to establish regulatory or tax incentives to encourage the reuse of recycled materials. ☐ ☐

3.4 Undertaking or sponsoring research and development in the area of waste recycle. ☐ ☐

3.5 Bulking of small quantities of wastes and auctioning the bulked materials to the existing recycling industry. ☐ ☐

3.6 Installing equipment for the recycling of waste streams not now adequately dealt with by the private sector. ☐ ☐

3.7 Providing an information service to the recycling industry on the latest technical developments in recycling. ☐ ☐

3.8 Providing an information service on potential users of recovered materials and on sources of waste streams for recycle in Ontario. This might be in conjunction with the Canadian Waste Materials Exchange. ☐ ☐

3.9 Other roles you think might be useful to you:

Section 4 - Concerns About the Role of OWMC in Waste Reduction

Do you have any concerns about the roles which OWMC might adopt in this area? Are there any roles which you feel might be counterproductive to their stated aim of increasing the amount of waste materials reused in Ontario?

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